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Technological Interventions and Applications in Agriculture

Food Quality and Product Development

Community and Environment

Analysis of the Association Between the Stem Bark Anatomy and Peelability of Cinnamon

Kumara D.U.S., Mohotti A.J.*, Benaragama C.K.[1], Suriyagoda L.[1] and Jeewandara P.[2]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) has a high demand in the global market due to its unique properties and health benefits. Cinnamon processing is a time and labour consuming process. Peelability of cinnamon bark is known to depend on the climatic conditions, maturity of the stem and variety, but still an unexplained phenomenon. The objective of this study was to identify a relationship between peelability of the stem and its anatomy. Same aged stems of cinnamon variety *Siri Gemunu* were collected during different times of the year when it was peelable (during wet weather and when bearing light green colour leaves) and non-peelable (when bearing flowers or fruits). Cross sections of the stems were taken and slides were prepared, and images were taken using a light microscope mounted with a digital camera. Anatomical measurements were made with these images using Image J software. Cambium layer thickness, outer bark thickness, inner bark thickness, stone cell layer thickness and mucilage cell count per unit area were taken as anatomical measurements. The mucilage content of the bark was also determined. There was no consistent relationship with the peelability and the anatomical measurements. However, the bark mucilage content of the cinnamon sticks sampled during wet weather, and from plants bearing light green leaves were higher than the mucilage content in the non-peelabe sticks (bearing flowers or fruits) ($P<0.05$). In conclusion, bark mucilage had a positive relationship with peelability of cinnamon, which warrants to be studied further.

Keywords: Ceylon cinnamon, Bark anatomy, Mucilage content, Peelability

The support received from the Director General and the Assistant Director-Nillamba Regional Centre of the Department of Export Agriculture Department in collecting samples greatly acknowledged.

[1]Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
[2]Botany Department, Department of Ayurveda, Nawinna, Maharagama

* mohottij@yahoo.com

Assessment of Efficacy of Electrical Water Bath Stunning on Welfare and Meat Quality of Broiler Chickens

Premasiri M.W.R.C., Bandara R.M.A.S.[1], Nishshanka N.A.K.C.[2], Adikari A.J.M.A.D.[2], Chathuranga T.G.S.[2] and Samarakone T.S.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Stunning prior to slaughtering is practiced to minimize pain and suffereing of farm animals. In this study 2 different electrical parameters (high intensity and high voltage current: 400mA-600mA and 40V; low intensity and low voltage current: 200mA-400mA and 20V-25V) with a constant frequency (280Hz-300Hz) were assessed to detect the efficacy of water bath stunning and meat quality of broiler chickens (Body wt: 2.0±0.2 kg, 35±2 days old). There was no difference in pre-stunnig stress between the two treatment groups ($P>0.05$). Efficacy of stunning was detected by assessing presence of reflexes and behaviours of the birds. None of the birds exhibited eye blinking, head shaking, look around and neck muscle tone just after stunning and just before neck cutting for the high electrical parameters. However, nearly 4% of birds showed these reflexes and behaviours for the low electrical parameters indicating lower stunning efficacy. Mean time to loss of reflexes and behaviours after neck cut indicated faster death in stunned birds than in the conscious birds evaluated. The stunned birds started regain of consciousness in less than 4 minutes and fully recoverd within 5 minutes for both the electrical parameters. Carcass quality assessment revealed that higher number of birds stunned with high electrical parameters had blood spots in wings and hemorrhages in the breast ($P<0.05$). Based on the meat quality assessment, there was an interaction effect of electric current and conscious state of the birds on the ultimate muscle pH. However, the electrical parameters did not affect on color values and water holding capacity of the broiler chicken meat. Stunned birds had lower water holding capacity (55.75±0.63) than regained conscious birds (58.34±0.59) ($P<0.05$). In overall, high electrical parameters were more efficient in water bath stunning to achive humane slaughtering. However, the high electrical parameters comparatively reduced the meat quality of broiler chickens.

Keywords: Broiler chickens, Pre-stunning stress, Electrical water bath stunning, Reflexes, Humane slaughtering

[1]Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka
[2]New Anthoney's Farms (Pvt) Ltd. Hanwella
* thusiths@pdn.ac.lk

Assessment of Forage Value of Invasive *Petiveria alliacea* for Ruminant Feeding

Jayarathne D.T.S.V., Kumara Mahipala M.B.P.* and Weerasinghe W.M.P.B.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rapidly spreading *Petiveria alliacea* is an invasive, perennial, herb native to the American continent. The herb has already become a troublesome weed in the farm lands in Kandy and Matale districts. The present study assessed the potential of *Petiveria alliacea* for ruminant feeding. Randomly selected *Petiveria alliacea* and *Panicum maximum* (control) plants from the University Experimental Station, Dodangolla were harvested. The experimental design was Complete Randomized Design (CRD) with 6 replicates. The oven dried samples were ground and laboratory samples were prepared. Proximate composition, in-vitro organic matter digestibility (OMD), in-vitro metabolizable energy (ME) content and biological effect of tannins were determined. In-vivo feeding experiment was conducted to study the effect of inclusion of *Petiveria alliacea* in a total mixed ration (TMR) for goats. The experimental design was CRD with 4 replicates. Two isonitrogenous and isoenergy, TMR were prepared using *Petiveria alliacea* (with or without), *Panicum maximum* and coconut meal. In-vivo dry matter digestibility (DMD) and in-vivo OMD of rations were compared. Crude protein content, in-vitro OMD and in-vitro ME content of *Petiveria alliacea* were greater ($P<0.05$) compared to *Panicum maximum*. However, due to the biological effect of tannins present in *Petiveria alliacea*, its OMD and ME content were reduced ($P<0.05$). Inclusion of *Petiveria alliacea* in TMR did not influence ($P>0.05$) the feed intake, in-vivo DMD and in-vivo OMD. The in-vivo OMD of both TMR were greater ($P<0.05$) than respective in-vitro OMD. The study concludes that *Petiveria alliacea* is a protein and energy rich, more digestible forage compared to *Panicum maximum* for ruminant feeding. Inclusion of 35% *Petiveria alliacea* in TMR for feeding goats is feasible, economical and therefore, recommended. After the anaerobic microbial digestion of feed in the complex stomach, continuation of considerable enzymatic digestion of organic matter along the digestive tract in goats was evident.

Keywords: Proximate composition, Digestibility, Metabolizable energy, Biological effect of tannins

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[1]Division of Pasture and Fodder Crops, Veterinary Research Institute, Gannoruwa, Peradeniya

* pmahi@pdn.ac.lk

Assessment of the Nitrogen Release Patterns of Different Controlled Released and Stabilized Urea-Based N Fertilizers and Their Impact on the Productivity and Nitrogen Use Efficiency of Maize (*Zea mays* L.)

Senevirathne S.M.P., Nissanka S.P.* and Gunawardana M.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Nitrogen use efficiency (NUE) of irrigated maize (*Zea mays* L.) ranges from 25-50% due to heavy losses of applied N. Use of controlled released fertilizers (CRF) and urea stabilizers are commonly adopted methods to enhance the NUE. Two experiments were conducted to evaluate the performance of CRFs. A field experiment at Dodangolla Experimental Station, Sri Lanka was conducted with 10 treatment combinations to examine the agronomic efficiency of N (AE_N) in irrigated maize. Two CRFs (single polymer coated and double polymer coated), were used with and without DCD and NBPT (DCD- [Dicyandiamide] and NBPT- [N-(n-butyl) thiophosphorictriamide]), under 2 rates of urea (100% and 50% of Department of Agriculture [DOA]recommendation) and a no nitrogen applied control. DCD and NBPT rates were 10% and 1% of urea nitrogen amount (weight basis), respectively. A leaching column experiment was conducted to evaluate the N release patterns of CRFs. Two double polymer coated CRFs (with 1% and 3% polymer loading [weight basis] respectively) were evaluated with and without DCD and NBPT, in 6 treatment combinations. Results of the field experiment showed a 31.5% increase in AE_N of coated, 50% N + stabilizer treatments with respect to 100% N treatments. Yields of the 50% N treatments were 20.3% lower compared to 100% N treatments ($P \leq 0.05$). There was no significant difference among the 2 CRF types regarding the yield and AE_N of maize. Results of the leaching experiment showed 19% reduction in N release of CRFs compared to uncoated urea after 2 weeks. CRFs showed no difference in N release among them ($P \leq 0.05$). Compared to uncoated urea, use of CRFs in combination with urea stabilizers showed promise in improving the NUE of maize. This could lead to a reduction in urea application for Sri Lankan maize cultivations in the future.

Keywords: controlled released fertilizer, agronomic efficiency of nitrogen, urea stabilizers, DCD, NBPT

[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama
* spn@pdn.ac.lk

Characterization of Tomato Germplasm for Future Breeding Programs

Pemarathna M.A.S.K., Wasala S.K.[1*] and Eeswara J.P.
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tomato (*Solanum lycopersicum* L.), belongs to family Solanaceae, is a widely grown and consumed vegetable in Sri Lanka. Plant Genetic Resources Centre, Gannoruwa, Peradeniya conserved the majority of tomato diversity in Sri Lanka. This experiment was conducted at the open field of Plant Genetic Resources Centre, Gannoruwa, Peradeniya to characterized 96 conserved accessions and four recommended varieties using the descriptors for vegetables and condiments which has 36 qualitative and quantitative morphological characters. According to the results, seven types of fruit shapes were identified. Fruit length and width varied according to the fruit shape and size. According to the exterior colour of riped fruits, 55% belonged to red and accession 012976 was yellow. The number of locules varying according to the genotype. A higher number of locules was found in *Goraka* accessions. Thilina had the highest per plant yield up to the third harvest (3.05 kg) with 97 g of average individual fruit weight. *Goraka* type accessions, 000272, 012765, 013366, and 016026 had comparatively larger fruits but the number of fruits was less. Accessions 001940, 013124, 013335 and 014759 had higher pericarp thickness and 001652, 001926, 001940, 001967, 011197 and 013335 were higher in firmness, which are important traits to reduce post-harvest losses. Brix values of accessions were within the accepted range (3.0 to 6.0) and the pH value of juice was above 4.0 for most of the accessions. The dendrogram obtained with morphological characters separated into three major clusters at a Rescaled distance of 15. The largest first cluster was containing 77 accessions including four recommended varieties. The second cluster contained 17 accessions of *Goraka* type tomato. The third cluster was the smallest with two accessions 000523 and 016025 of *Goraka* type tomato. These results are very much important for systemic germplasm conservation and utilization for variety development.

Keywords: Accession, Diversity, Morphological characters, Tomato

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[1] Plant Genetic Resources Centre, Gannoruwa, Peradeniya
* samanthiwasala@gmail.com

Comparative Effect of Synthetic and Organic-Based Controlled Release Fertilizers on Growth and Yield Performance of Potato (*Solanum tuberosum* L.) in the Up-Country Wet Zone (WU3) of Sri Lanka

Siriwardhana E.L.D.A.N., Fonseka R.M.* and Abeytilakarathna P.D.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Potato (*Solanum tuberosum* L.) is the world's most important root and tuber crop. A successful potato crop depends on judicious cultural practices. Sri Lankan Potato farmers are known to apply two to three times more inorganic fertilizers than the recommendation of Department of Agriculture (DOA) which destroys the soil and the environment. A pot experiment was conducted in plant house during *Maha* 2019/2020 at Sita-Eliya (SE), Nuwara-Eliya, which is the major potato cultivating region of Sri Lanka. Potato variety Granola was grown with seven treatments in five randomized replicates. T_0-No fertilizer/manure (Control), T_1- Department of Agriculture (DOA) recommended inorganic fertilizer, T_2- 25% DOA recommended inorganic fertilizers + 75% Organic-based Controlled-release fertilizer (Trade name: Biocarbon). T_3- 50% DOA recommended inorganic fertilizers + 50% Organic -based Controlled-release fertilizer, T_4-75% DOA recommended inorganic fertilizers + 25% Organic-based Controlled-release fertilizer, T_5 - Organic-based controlled-release fertilizer only and T_6- DOA recommended organic and inorganic fertilizers. The percentages were determined based on total weight of DOA recommendation. The vegetative, growth and yield parameters measured were plant height, canopy diameter, leaf number and number of stems. Total tuber yield and marketable yield were measured as yield parameters. Out of all the vegetative parameters measured, T_6 gave the highest mean value which was significantly different from other treatments except for the number of stems. There was no significant difference in the marketable yields of T_4 and T_1 where same amounts of organic and inorganic fertilizers were separately applied. This study should be repeated for several seasons to get a better understanding on the effect of combination of organic based slow releasing fertilizer and synthetic fertilizers while improving soil physical properties. An economic analysis of the costs: benefits of the treatments would also be beneficial for future evaluations.

Keywords: Organic, Potato, Synthetic fertilizer, Yield

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[1]Department of Agriculture, Agricultural Research Station, Seetha Eliya

* ramyamf@gmail.com

Comparison of Growth and Yield of Selected Hybrid Fodder Varieties Planted at the end of Maha Season in Thunukkai of Mullative District of Sri Lanka

Kamalraj A., Kumara Mahipala M.B.P.* and Sinniah J.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Plant growth parameters and yield of selected hybrid fodder maize, sorghum and millet varieties planted at the end of Maha season (mid-February) in Thunukkai of Mullative were compared. Hybrid fodder maize (Pacific 984), sorghum (Sugargraze) and millet (Nutrifeed and Milk feed) varieties cultivated at the Regional Livestock Breeding farm in Anichiyankulam. The experimental design was Complete Randomized Design with 3 replicates. Pacific 984, Sugargraze, Nutrifeed and Milk feed seeds were planted with 45x20 cm, 45x15 cm, 45x15 cm and 45x30 cm space, respectively. Forages were harvested at 50% flowering stage. Plant height, leaf length, leaf width, leaves number, stem girth, internode length and fresh fodder yield were measured. Plant age, growth parameters and yield at maturity associated ($P<0.05$) with forage variety. Nutrifeed and Milk feed reached maturity around ninth weeks while Pacifc 984 and Sugergraze reached maturity around tenth weeks. Both Pacific 984 and Sugargraze had significantly ($P<0.05$) taller plants (246.6±3.52 cm and 238.3±2.02 cm), longer leaves (113.6±6.38 cm and 101.6±1.45 cm) and wider leaves (9.1±0.16 cm and 9.0±0.57 cm) compared to millet varieties. Pacific 984 had the highest ($P<0.05$) number of leaves (12.0±1.00) and stem girth (8.3±0.66 cm). Nutrifeed and Milk feed were not significantly different ($P>0.05$) in terms of leaf length (78.0±4.93 cm and 74.0±5.85 cm), leaf width (3.5±0.28 cm and 3.5±0.76 cm), stem girth (3.0±0.01 cm and 3.5±0.28 cm) and yield (66.6± 2.2 MT/ha and 74.1±6.25 MT/ha). As a result of superior plant growth parameters, Pacific 984 (97.1±5.99 MT/ha) and Sugergraze (94.2±2.29 MT/ha) produced greater ($P<0.05$) fresh fodder yield compared to Nutrifeed (66.6±2.2 MT/ha) and Milk feed (74.1±6.25 MT/ha). However, it is suggested to estimate dry matter yield and nutritive value of hybrid fodder varieties before recommending them to cultivate in Thunukkai of Mullative district.

Keywords: Pacific 984, Sugargraze, Nutrifeed, Milk feed, Fresh fodder yield

[1]Faculty of Agriculture, University of Jaffna, Ariviyal Nagar, Kilinochchi

* pmahi@pdn.ac.lk

Determination of The Relationship Between Peelability and Water Relations of Cinnamon

Wickramasingha P.A.S.C., Benaragama C.K., Suriyagoda L. and Mohotti A.J.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cinnamon (*Cinnamomum zeylanicum* Blume) is one of the highest export earning spice crops in Sri Lanka. Peeling of cinnamon bark is a highly skilled technique which has been handed down from generation to generation. The peelability of cinnamon bark is known to change with the weather, maturity of the stem and variety. However, the physiological reasons behind the peelability have not been identified yet. Therefore, the present study was conducted to determine the relationship between peelability and water relations of cinnamon. Cinnamon sticks and leaves were sampled from peelable and non-peelable plants. When stems were collected during wet weather and, when bearing immature and light green colour shoots, they were peelable. Plants bearing immature and reddish colour shoots, bearing flowers or seeds, '*weli kurundu'* which have a rough bark, and when collected during dry weather were non-peelable (difficult to peel). Peelability of cinnamon sticks were measured by estimating the force required to remove bark (de-barking force). Leaf water potential, hydraulic conductivity of the cinnamon sticks, soil moisture content, and moisture content of the cinnamon sticks and leaves were also measured. There were significant differences between the treatments in the de-barking force, hydraulic conductivity and leaf water potential values ($P<0.05$). Hydraulic conductivity exhibited a significant, strong, negative correlation with de-barking force ($P<0.05$). There were no significant correlations between the leaf water potential, soil moisture content, leaf moisture content and stem moisture content with the de-barking force ($P<0.05$). It can be concluded that the peelability is strongly associated with hydraulic conductivity of the stem. The factors influencing the hydraulic conductivity in cinnamon stems warrants to be studied further.

Keywords: Ceylon cinnamon, Hydraulic conductivity, Leaf water potential, Peelability

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* mohottij@yahoo.com

Does Physiological Maturity at Harvesting Affect the Action of Postharvest Application of Ethylene in Cavendish Banana?

Subasinghe S.M.J.C., Benaragama C.K.*, Wasala W.M.C.B.[1] and Dammullage I.[2]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Effect of different ethylene concentrations on different maturity stages was investigated on postharvest quality of Cavendish banana (*Musa acuminate* cv. Grande Naine). Mature banana fruits, at the age of twelve-weeks, thirteen-weeks and fourteen-weeks after flowering were treated with 0, 85 and 170 ppb concentrations of ethylene for 24 hours at 24 ˚C and under 75% RH. After 24 hours, bananas were stored at ambient temperature (26±2 ˚C). Physicochemical properties (pH, firmness, total soluble solids-TSS, titratable acidity-TA, peel color, flesh color) and sensory properties (peel color, flesh color, taste, texture and overall acceptability) were determined in ripening-induced banana. Data obtained for physicochemical properties were subjected to ANOVA and the sensory properties were analyzed using Kruskal-Wallis test. There was a significant interaction effect between maturity stage and ethylene concentration on weight loss, TSS and TA at the table-ripe stage. The fruit losts its weight steadily upto 8.5%, possibly because of the rapid metabolism and high transpiration rate of the fruit, which coincided with the fruit firmness that was reduced from 2.8 kg cm^{-2} at the firm-mature to 0.3 kg cm^{-2} at the table ripe stage. Yellowness of banana peel as measured by the b* value, increased with ripening in all treatments. TSS increased from 4% to 20%. Moreover, pH decreased and titratable acidity increased gradually. The best sensory properties were recorded in the bananas harvested 12 weeks after flowering and treated with 85 ppb of ethylene.

Keywords: Cavendish banana, Ethylene, Maturity, Postharvest quality

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[1]National Institute of Post-harvest Management, Anuradhapura
[2]CIC Seed (Pvt.) Ltd., CIC Seed Farm, Palwehera, Dambulla
* chalindab@gmail.com

Economic and Technological Feasibility of Using an IoT-Based Automated Fertigation in Vegetable Crop Cultivation Under Semi-Intensive Greenhouse Conditions in Sri Lanka

Dilrukshi R.P.W.A., Weerakkody W.A.P.* and Gunawardana D.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Internet of Things (IoT) is one of the emerging technical advancements practiced in the field of protected agriculture. IoT-based automated systems are associated with monitoring and controlling of agricultural operations which are connected to the Cloud that abate manual inspections. Farmers feel more comfortable with IoT-based automation in protected culture operations because of their economic and productivity benefits. Therefore, an IoT-based fertigation system with an automated soil moisture sensor (ASMS) was trialed out to determine its economic and technological feasibility in vegetable crop cultivation under semi-intensive greenhouse conditions in Sri Lanka. Tomato (*Solanum lycopersicum* L.), bell pepper (*Capsicum annuum* L.) and salad cucumber (*Cucumis sativus* L.) were grown hydroponically in side-by-side trials in a glasshouse, while comparing ASMS-based fertigation with grower-managed manual fertigation. ASMS-based fertigation was operated according to pre-defined medium moisture thresholds ensuring optimum water application to plants using a drip irrigation system. Crop growth, yield, fruit quality and irrigation water use efficiency were monitored in the experiment. Compared to manual fertigation, ASMS-based fertigation resulted in a higher vegetative growth, number of fruits and fruit weight per plant in all three crops. Moreover, the early fruit yields of tomato, bell pepper and salad cucumber were 16.1%, 5.1% and 15.8% higher, respectively, while the Brix values of fruits were lower under ASMS-based fertigation compared to manual fertigation. Reduction in irrigation water use, while providing adequate water for plant growth was noted under the ASMS-based fertigation system. Based on the results of the experiment, it can be concluded that ASMS-based micro fertigation system appears to be more feasible with respect to growth, yield, water use and labour cost, compared to manual fertigation.

Keywords: ASMS-based fertigation system, Internet of Things (IoT), protected agriculture

[1]Dialog Axiata PLC, Colombo

* palithaw@pdn.ac.lk

Effect of Aqueous Leaf Extracts of *Artemisia vulgaris* L. on Growth and Development of Nursery Tea Plants [*Camellia sinensis*(L.) O. Kuntze]

Sayanthan T., Jayamali B.G.A.C.[1], Marambe B.[*], Mohotti A.J., Mohotti K.M.[2], Suriyagoda L., De Silva M.S.D.L.[2], Amarasena P.G.D.S.[2] and Jananey B.[2]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Organic based weed control options are important in tea [*Camellia sinensis*(L.) O. Kuntze] to meet pesticide-residue monitoring standards of made-tea in importing countries. Previous studies have shown the weed control potential of aqueous leaf-extracts of *Artemisia vulgaris* L. in tea lands. This research evaluated the non-target phytotoxicity of aqueous leaf-extracts of *A. vulgaris* at 25, 50, 75 and 100 g/L (soil-applied, 40 ml/pot) on growth of 7-months old nursery tea plants (TRI 4006 and 4046) in polythene bags with 1 kg topsoil. Results were compared withsoil-applied recommended doses of systemic (Glyphosate, Diuron, and MCPA) and contact (Pelargonic acid, Pine oil and Glufosinate Ammonium) herbicides, with distilled water as the control. Experiments were done in CRD with five replicates, with 1 plant/replicate. Leaf greenness (SPAD meter) at 20 days after treatment (DAT), number of leaves, total root length, and shoot and root dry weights/plant were counted/measured with destructive sampling done at 30 DAT. Histological studies were conducted using split-root technique and microscopic observations were done 3 months after treatment. *Artemisia* leaf extracts did not show significant negative impacts on aboveground parameters of tea plant compared to control. The highest phytotoxicity was with MCPA (root cell damage; 100% mortality). The SPAD readings showed significant leaf chlorosis in TRI 4006 and 4046 with Diuron (28 and 29) and Glufosinate Ammonium (20 and 5), compared to control (40 and 38), *Artemisia* extracts (42 and 40), Pelargonic acid (47 and 45) and Pine oil (45 and 34), with Glyphosate recording higher leaf greenness (61 and 51). Histological changes and cell damages in roots were observed with 100 g/L *Artemisia* leaf extract, at comparatively low degree to herbicides. As non-target effects of *A. vulgaris* on tea plant were comparatively lower, further studies are warranted to determine effective dosage with least impact on tea and environment.

Keywords: *Artemisia vulgaris*, Aqueous leaf extracts, *Camellia sinensis*, Histological and growth studies, Non-target effects

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[1]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya
[2]Tea Research Institute of Sri Lanka, Talawakelle

* bmarambe@pdn.ac.lk

Effect of Biochar and Compost Application on Organic Carbon Fractions of a Corn Growing Alfisol in Dry Zone of Sri Lanka

Logarasa L., Munasinghe S.T.[1], Vidana Gamage D.N. and Dharmakeerthi R.S.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The effect of quality and quantity of organic matter added on organic carbon (OC) contents in soil and different soil organic matter (SOM) fractions of a corn growing Alfisol in the dry zone of Sri Lanka were determined. Biochar made from rice-husk (RH-BC) and corn cob (CC-BC), and compost made from groundnut waste were used along with chemical fertilizers in a field experiment conducted using corn as the test crop for 4 seasons. Biochar was applied at 17 Mg/ha only in the first season and compost was applied at 10 Mg/ha in each season. Plots with no organic amendments were maintained as the control treatment. Total OC (TOC) contents in bulk soil and density fractions of SOM were measured soon after treatment application and again at the end of the 4th season. Permanganate oxidizable carbon contents were also measured and carbon management index (CMI) was calculated. Application of biochar significantly increased ($P<0.001$) TOC contents and stocks in bulk soil by 22-33% when compared to compost added treatments soon after application due to high OC contents in biochar (41-63%). In all treatments TOC contents in the bulk soil decreased by the end of the 4th season from about 19% on average. Among different SOM fractions the light fraction OC content was significantly higher ($P<0.01$) in biochar added treatments soon after application. After the 4th season TOC in both light and occluded fractions of RH-BC added treatment were significantly high. Single application of CC-BC and RH-BC increased CMI by 27% and 72%, respectively, while repeated compost addition did not significantly increase ($p>0.05$) CMI (6%) by the end of 4th season. Therefore, of the 3 organic amendments evaluated, application of RH-BC is the best short term SOM management strategy for corn growing Alfisols in the dry zone of Sri Lanka.

Keywords: Biochar, Compost, Soil organic carbon, Density fractionation, Carbon Management Index

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[1]Grain Legume and Oil Crop Research and Development Centre, Department of Agriculture, Angunakolapellasa

* dharmakeerthirs@gmail.com

Effect of Dietary Protein Level of Dry Pellet Feed Prepared with Selected Locally Available Ingredients on Mud Crab (*Scylla serrata*) Fattening

Perera H.L.D., Madhubhashini E.T.S.* and Nilwala N.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The study was conducted to develop a cost-effective formulated dry pellet for mud crabs (*Scylla serrata*) fattening using selected locally available fish meal, shrimp head meal, soybean meal, coconut meal, wheat flour, canola oil, and feed additives. The nutritional performance in terms of growth, feed utilization, protein efficiency, survival rate, and the moulting frequency of crabs were assessed. In the preliminary experiment, 3 out of 5 ration formulations were selected considering the acceptability by mud crabs and water stability of feeds. The feeding experiment consisted formulated dry pellet rations with 3 different crude protein (CP) levels (29%, 33%, and 38%) and a control feed (Trash fish). Vertical culture racks were prepared with one crab per box. There were 6 replicates per treatment. The average body weight of juvenile mud crabs used was 61.27±10.83 g. They were fed with respective experimental feed at 8% of body weight twice a day during the one-month feeding trial. The best growth performance ($P<0.05$) was recorded in crabs fed with 33.56% CP containing pellets. The feed conversion ratio of crabs fed with 33.56% CP containing pellets was not significantly different ($P>0.05$) from the crabs fed with 38.24% CP containing pellets. The protein and lipid efficiency of crabs fed with the control feed were significantly higher ($P<0.05$) compared to crabs fed with formulated dry pellets. The crabs fed with 29.41% CP containing pellets and control feed showed 100% survival rate. The protein content of crabs fed with 33.56% CP containing pellets was significantly higher ($P<0.05$) than the other experimental feeds. The growth performance, preference of the mud crabs, and the convenience of usage of dry feed pellets were comparatively higher than trash fish.

Keywords: *Scylla serrata*, fattening, formulated feed, fish meal, shrimp head meal

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[1]Ministry of Agriculture, Land, Irrigation, Fisheries, Animal Product & Health and Agrarian Development, Western Province

* thushanis@pdn.ac.lk

Effect of Different Concentrations of 17α – Methyltestosterone on Sex Reversal of Female Dwarf Gourami

Edirisinghe E.P.S.K.K., Athauda A.R.S.B.* and Mudalige A.R.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Many fish species in ornamental fish industry show sexual dimorphism, mostly resulting male fish to be more colorful than the female fish. Dwarf gourami (*Trichogaster lalius*) is such species trading the male fish twice the price of a female in Sri Lankan ornamental fish industry. This study was conducted to obtain the optimum concentration of 17α- Methyltestosterone (MT) for the sex reversal of *T. lalius* female through immersion treatment in order to obtain all male population. MT concentrations of 750 μgL^{-1}, 1,000 μgL^{-1}, 1,250 μgL^{-1} and 1,500 μgL^{-1} were used for immersion treatment for 3 h period at third, fifth and eighth day after hatching. The experiment was conducted throughout 150 days after hatching. The concentrations of MT 1,500 μgL^{-1} and 1,250 μgL^{-1} resulted in 93.6 % and 87.9 % male population respectively which was significantly ($P<0.05$) higher than the rest of the concentrations. The concentrations of MT 1,000 μgL^{-1}, 750 μgL^{-1} and the control resulted in 81.5 %, 72.4 % and 39.1 % male population, respectively. All of the MT concentrations gave significantly ($P<0.05$) higher male population than the control. Even though, the concentration1,500 μgL^{-1} resulted the highest male percentage numerically, the survival rate was 16.7 % which was the lowest ($P<0.05$) compared to the other treatments. The concentration of 1,250 μgL^{-1}, 1,000 μgL^{-1}, 750 μgL^{-1} and the control resulted in 50.6 %, 63.3 %, 68.3 % and 83.9 % survival rate, respectively. Therefore, the most suitable concentration of MT for sex reversal of dwarf gourami is 1,000 μgL^{-1}. This study was on hold temporarily (Mid-March, 2020 onwards) due to COVID-19 pandemic before evaluating the effect of 17α- MT on sex reversal, therefore further study with similar and higher concentrations might achieve 100 % sex reversal of *T. lalius* with higher survival rate.

Keywords: 17α- Methyltestosterone, *Trichogaster lalius*, Masculinization, Sexual dimorphism

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[1]National Aquaculture Development Authority Dambulla Center, Dambulla

* sbathauda@pdn.ac.lk

Effect of Elevated Ambient Temperature on Physiological and Quality Parameters, and Soil Properties of Organically and Conventionally Managed Tea Fields (*Camellia sinensis*(L.) O. Kuntze)

Widulanka A.K.A.K.S., Wijeratne T.L.[1], Amarasena P.G.D.S.[1], Piyasena N.[1], Nissanka S.P., Mohotti A.J.* and Mohotti K.M.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tea is the major export earning crop in Sri Lanka, contributing to around 0.7% to the GDP. Increasing temperatures resulted by global warming is expected to act negatively on the physiological processes resulting in crop losses in future. The objective of this study was to assess the effects of increased temperature on some selected physiological and quality parameters of tea and soil of organically and conventionally managed tea. The study was conducted at the 'TRIORCON' long-term organic and conventional comparison trial, St. Coombs Estate, Talawakele. Climate change simulating structures were mounted using a metal frame enclosing 20 tea bushes as plots, and differentially covering with transparent polythene. Three treatments, viz. fully enclosed (3-4.5 ^{o}C temperature increase), partially enclosed (1-2 ^{o}C temperature increase) and open (ambient temperature) were established at both organic and conventional plots. physiological parameters namely, photosynthesis rate, leaf water potential and hydraulic conductivity, tea quality parameters namely, total polyphenols and organoleptic evaluations by an expert tea tasting panel and also soil physical (soil moisture content) and chemical parameters (N, P, K, and organic matter content) were measured. The physiological parameters did not show a difference between organic and conventional treatments. However, the increasing temperature increased the rate of photosynthesis and stomatal conductance, despite decreased leaf water potential and Water Use Efficiency. Increasing temperature clearly decreased the quality of the made tea, decreasing tea taster's ratings. Organic tea had higher and lower percentages of active and *banji* shoots respectively in the harvest, but conventional tea had a slightly better quality compared to organic tea. Organic plots had a higher soil organic carbon content and pH, and there was no difference in the other soil parameters. It can be suggested to study these parameters further with more replicates in order to confirm the results.

Keywords: Climate Change, Organic system, Conventional System, High Temperature, Physiological Parameters

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[1]Tea Research Institute of Sri Lanka, Talawakelle

* mohottij@yahoo.com

Effect of Home Thermal Environment on Cardinal Temperatures for Pollen Germination and Pollen Tube Growth of Coconut (*Cocos nucifera*)

Somathilaka S.R.P.M., Weerasinghe K.W.L.K.* and Kumarathunge M.D.P.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was conducted to investigate germination percentage and pollen tube growth of coconut variety CRIC 60 under variations in plants' home thermal climates. Samples were collected from coconut plantations from six different agro-ecological regions, namely, Bandirippuwa estate (IL1a), Puttalam (DL3) and Maduruoya (DL1c), representing relatively warmer climates in the Dry Zone (DZ) and Doluwa (WM2b), Bowala (WM2b) and Paradeka (WM2a) representing relatively cold climates in the Wet Zone (WZ) of Sri Lanka. At each location, male flowers of all six palms of CRIC60 were pooled to make three replicated samples. Subsequently, a mathematical model was fit into describe the temperature response of pollen germination and pollen tube growth. According to results, growth temperatures showed a significant ($p<0.05$) effect on pollen germination percentage. Optimum temperatures (T_{opt}) for pollen germination of warm climatic regions were higher than the T_{opt} for that of relatively cold climatic regions. Further, there was a significant relationship between pollen tube length and growth temperature. A low T_{opt} for pollen tube growth was observed for relatively cold home climates than the warm home climates. The T_{opt} for both pollen germination percentage and pollen tube length were relatively lower for WZ sites than DZ sites. The maximum pollen germination percentages of relatively cold regions were higher than the maximum pollen germination percentages of relatively warmer regions. Ω (the temperature difference from T_{opt} where the pollen germination rate falls to 37%) for pollen tube length had a significant relationship with growth temperature, however, similar relationship was not observed in the case of Ω for pollen germination. Moreover the relationship between pollen germination percentages and growth temperatures showed relatively narrow curves perhaps due to low Ω values. It can be concluded that pollen germination and pollen tube growth of CRIC 60 has better adapted to their home thermal climates.

Keywords: CRIC 60, Home Climate, Pollen Germination, Pollen Tube Growth

[1]Plant Physiology Division, Coconut Research Institute, Lunuwila

* lasanthaw@pdn.ac.lk

Effect of Paclobutrazol on Growth and Flowering of Parrot Impatiens (*Impatiens niamniamensis*)

Rasanga M.A.S., Eeswara J.P.* and Senaratne M.M.D.J.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was conducted with the aim of developing *Impatiens niamniamensis* (Parrot impatiens) into a dwarf attractive plant with more flowers and more branches by controlling uneven flowering pattern and excessive stem elongation with the help of growth retardants and pinching.

Plants obtained from top cuttings of *I. niamniamensis* were divided into two groups. Pinching was practiced for one group while the other group kept without pinching. Then the both groups were treated with four paclobutrazol concentrations (0 ppm, 5 ppm, 10 ppm, 20 ppm). The plants which were subjected to pinching, were pinched continuously until flower bud initiation. Paclobutrazol concentration significantly affected the plant height ($P<0.0001$) and canopy diameter ($P<0.0001$). Furthermore, pinching affected significantly to the canopy diameter ($P=0.0062$). Also interaction of pinching and paclobutrazol concentration was significantly affected to length of the branches. Best paclobutrazol concentration for all the parameters was 5 ppm. Both factors didn't affect significantly on number of days taken to flowering and leaf chlorophyll content. Plants which are treated with higher paclobutrazol concentration with and without pinching produced abnormal plants with abnormal leaves and flower buds. Plants treated with 5 ppm paclobutrazol concentration without pinching produced more attractive plants with more flowers (22.89± 2.76) and comparatively more branches (5.33± 0.77) and produced greener leaves than control plants. Therefore, application of 25 mL of 5 ppm paclobutrazol without pinching can be recommended as the best method for controlling height, produce more branches and flowers with better appearance of *I. niamniamensis*.

Keywords: Floriculture industry, *Impatiens niamniamensis*, Paclobutrazol, Pinching

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[1]Department of National Botanic Gardens, Royal Botanical Garden, Peradeniya.

* jpe@pdn.ac.lk

Effect of Shelterbelts on Production of High Quality Betel (*Piper betel* L.) Leaves

Wickramarathna R.D.S.M., Ranil R.H.G.* and Subasinghe H.M.P.A[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Betel (*Piper betel* L.*)* is considered as one of the popular export agriculture crops with a high economic value. Shelterbelts are used to change the microclimate around cultivated crops. They directly influence the biological and physiological processes of crops. This study was conducted to evaluate the effect of shelterbelts on growth and yield of betel and also to identify the ideal porosity level of the shelterbelts. The porosity of shelterbelts was manipulated by changing the distance between coconut cadjan. Coconut cadjan were established 06" (T2), 12" (T3) and 24" apart (T4) to make shelterbelts. Plots without shelterbelts were the controls (T1). The experiment was laid out in a RCBD with three replicates. Growth parameters and microclimatic data were recorded during the study period. The experiment was conducted at the Intercropping and Betel Research Station, Narammala. Results showed that leaf width, leaf length, number of leaves, number of lateral branches and vine height were significantly higher in all treatments when compared to the control ($P \leq 0.05$). The differences between three shelterbelt treatments were non-significant. In the same way, all growth parameters were significantly higher in shelterbelt treatments when compare with the control. Due to prevailed continuous rain during the study period and some personal and instrumental errors, microclimatic data collected were difficult to explain and interpret meaningfully. The study clearly shows that there is a significant effect of shelterbelt on growth performance and quality parameters of betel vine. Although farmers used shelterbelts against the evil eye and evil mouth in the early days, in reality there is a direct impact of shelterbelt on changing the microclimatic condition and thereby increasing the yield and quality of leaves.

Keywords: Betel, microclimate, shelterbelt and coconut cajans

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[1]Intercropping and Betle Research Station, Narammala

* rhgranil@gmail.com

Effect of Spacing and Biochar Application on Growth and Yield of Selected Sweet Potato [*Ipomoea batatas* (L.) LAM.] Varieties

Dharmasena W.U.S., Fonseka R.M.* and Karunananda D.P.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Sweet potato (*Ipomoea batatas* (L.) Lam) is the seventh most important food crop in the world. In many developing countries including Sri Lanka, sweet potato is used as a staple food crop because of its easy propagation, high yield and rich in nutrient content under varied climatic conditions. This experiment was aimed to evaluate the effect of spacing and biochar application on growth and yield of selected sweet potato varieties. The treatments were carried out using a three factor factorial experiment in a Split- Split- Plot design with two replications. The varieties (Wariyapola red, CARI 426, HORDI Malee) were placed on main plot, while plant spacing (row distance x plant-to-plant distance: 50 cm x 0 cm, 50cm x 20 cm, 50 cm x 30 cm,) were the sub plots and biochar doses (0t/ha, 5t/ha) were added to the sub sub-plots. The vine cuttings, about 20 cm in length were used as the planting material. Vine length (cm) and vine weight per plant were recorded at two weeks interval as vegetative growth parameters. Yield parameters; tuber yield (t/ha), tuber weight per plant, harvest index, shoot: root ratio were measured. Sweet potato weevil and rat damage were observed at the harvesting time. Data were analyzed using Statistical Analysis System (SAS), and ANOVA procedure was followed. The results revealed that the selected sweet potato varieties gave a significant response to the biochar application on tuber weight per plant, tuber yield, harvest index and shoot root ratio, but no interaction between variety × biochar, spacing × biochar, variety × spacing and variety × spacing × biochar. The variety HORDI Malee was the most performed variety in terms of yield parameters. 50 cm x 30 cm was the best spacing which gave highest tuber yield, tuber weight per plant and harvest index.

Keywords: biochar, spacing, sweet potato

[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya
* ramyamf@gmail.com

Effect of Transport Distance on Pre-slaughter Stress, Efficacy of Water Bath Stunning and Meat Quality in Broiler Chicken

Senanayake S.M.A.N.S., Bandara R.M.A.S.[1], Nishshanka N.A.K.C.[2], Adikari A.J.M.A.D.[2], Chathuranga T.G.S.[2] and Samarakone T.S.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Effective stunning of broiler chickens before slaughtering reduces pain and suffering, and improves welfare significantly. Objectives of this study was to assess the effect of transport distance on pre-slaughter stress, efficacy of water bath stunning (at voltage=20-30V, current=200-400mA, frequency=300Hz), and meat quality of broiler chickens (Body wt:1.8±0.2 kg, 35±2 days old) reared in closed houses which were located in three different distances to the processing plant (10 km: N=47, 75 km: N=41 and 130 km: N=35). Birds were rested for 30 minutes before slaughter at the lairage. Severity of panting was higher in the birds transported from 75 km distance, while severity of wing flapping at shackling was higher in the birds from 10 km distance ($P<0.05$) at the lairage. The reflexes and behaviors of the birds revealed that the efficacy of water bath stunning did not differ among the groups. The birds transported from 75 km exhibited longer time to lose many reflexes and behaviors after neck cut. Birds from 130 km distance regained consciousness significantly earlier than the other two groups. However, all birds from all distances regained consciousness within 4 minutes after stunning. Time to death was significantly low ($P<0.05$) in stunned birds than the birds which regained consciousness. High number of birds from 130 km distance had breast blood spots, wing hemorrhages, broken bones and high degree of wing tip damages. There was no significant difference in ultimate pH and meat colour (L*, a* and b* values) among the groups. Significantly high ($P<0.05$) water holding capacity of meat was observed in birds from 10 km (60.8±0.6%), followed by 130 km (57.6±0.7%) and in 75 km (54.5±0.1%). Results indicated that there was no effect of transport distance for the efficacy of water bath stunning and the birds transported from 130 km had low level of carcass quality.

Keywords: Broiler, transport, water-bath stunning, meat quality

[1]Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka
[2]New Anthoney's Farms (Pvt) Ltd. Hanwella
* thusiths@pdn.ac.lk

Enhancing Leaf Growth and Development in *Anubias* and *Cryptocoryne* by Controlling Growth Environment

Denipitiya H.W.S.D., Fernando W.A.S.[1] **and Benaragama C.K.**[*]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Anubias spp. and *Cryptocoryne* spp. are popular aqautic plants in aquascaping industry which are being exported from Sri Lanka. Slow growth rate of plants and less leaf area are the major issues in these two species that hinder bulk exports. *Anubias* takes more than eight months to reach up to a marketable size. Further, reduced leaf area in *Cryptocoryne* is the main issue in commercial *Cryptocoryne* cultivation. Light and nutrients are the main environment factors that affect on leaf development. In this experiment, *Anubias barteri* and *Cryptocoryne wendtii* "Brown" were exposed to 12 different fertilizer treatment combination of root applications (current practice, Albert solution, 20-20-20 fertilizer and alternative application of Albert solution and 20-20-20) and foliar applications (current application, Albert solution and no foliar application). Three species of *Anubias* (*Anubias* 'Nangi', *A. hesitifolia* and *A. barteri* 'Nana') and three species of *Cryptocoryne* (*C. wendtii* "green", *C. wendtii* "Brown" and *C. lutea*) were exposed to four different supplemental light levels (red, blue, white and current practice). Experimental design was split plot design. Parameters observed and measured included mean leaf area, leaf length, leaf width, plant height, number of leaves and root/shoot ratio. Nutrient solution and supplemental light level affected the leaf development of *Cryptocoryne* spp. However, the treatment effects on *Anubias* spp. were not observed during the experimental period due to their slow growth rate.

Keywords: *Anubias*, *Cryptocoryne*, supplemental light, leaf, nutrient

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[1]Ruvini Aqua Plants Lanka Ltd., 55/6, Koralawella, Moratuwa

* chalindab@gmail.com

Evaluation of Different Fertilizer Treatments on Microbial Population Dynamics in Paddy Soil and Root Growth Performance in Rice

De Silva P.T.D., De Costa D.M.*, Dharmakeerthi R.S.[1] and Rathnayaka U.K.[2]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The present study was conducted to determine the effect of different fertilizer treatments (i.e. inorganic, bio and slow releasing fertilizer (SRF)) on the density and diversity of microorganisms in treated paddy soils and root area and root dry weight of rice plants. Soil samples were collected separately from eight different fertilizer-treated paddy soils at early and late reproductive phases (1st and 2nd sampling) and ripening phase (3rd sampling). Dilution plate technique was used to isolate and quantify culturable soil microorganisms. Using biochemical tests and diagnostic media, bacterial diversity was determined for their Gram status and phosphorus solubilization and fluorescent pigment production ability. Fungi were identified by morphologically. The density and diversity of bacteria were higher than those of fungi in soils under eight treatments at all 3 samplings. Total bacterial and fungal populations were significantly differed among the fertilizer treatments and at 3 samplings. Bacterial colony diversity was highest at the late reproductive phase. In total, 48 morphologically-different bacterial colonies were isolated and 90% of them were Gram positive. The phosphorus solubilizing bacteria were isolated from Treatment 3 (100% NE; N-Urea, P-TSP, K-MOP) at the late reproductive phase and ripening phase and from the Treatment 2 (100% DOA; N - Urea, P-TSP and K-MOP) at the ripening phase. The fluorescent pigment producing *Pseudomonas* were not detected in any treatment. Fungal diversity in the rhizosphere was declined from reproductive phase to ripening phase of the rice crop. Considering the results, Treatment 4 (65% NE; N-SRF, P-TSP, K-MOP) has the highest fungal diversity and there were no isolated fungal species in Treatment 3. Significantly larger root area was observed in plants under Treatment 2. Significantly higher dry weight of roots was reported from Treatments 2, 3 and 5 (65% NE; N-SRF, P-TSP, DOA- K, PSB, Cyanobacteria) than the rest of five treatments.

Keywords: Diagnostic media, Dilution plate technique, Phosphorus solubilizing bacteria

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[1]Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
[2]Rice Research and Development Institute, Bathalagoda, Ibbagamuwa

* devikadecosta@gmail.com

Evaluation of Eco-Friendly Fertilizer Technologies on Growth Performance, Pest and Disease Resistance and Defence Enzyme Activity of Rice

Perera H.D.D., De Costa D.M.*, Dharmakeerthi R.S.[1] and Rathnayaka.U.K.[2]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The present study was conducted to evaluate the effect of six different eco-friendly fertilizer technologies (EFTs) on growth performances and pest and disease resistance, in comparison to presently-practiced fertilizer recommendations using rice (variety Bg 352) under field conditions. Number of tillers and productive tillers, percentage plants with panicles at 74th days after seeding, pest and disease incidence and severity were recorded. The highest tiller number was given by the present fertilizer recommendation (T2) and treatment T3, which is a site-specific nitrogen application. The highest productive tiller number was given by T3, T2, T6 and T5 treatments, with no significant difference among each other. Treatments T5 and T6 contained 65% of the site specific nitrogen requirement and supplemented with bio- and slow-released fertilizer applied at different times. The highest number of plants with initiated panicles were recorded by T1 (no nitrogen, no phosphorous but with DOA- potassium as MOP), T4 (65 % of the site specific N requirement) and T5 with no significant difference among each other. Brown spot disease and Whiteheads were identified as diseases and pest damages. Incidence of brown spot disease was not significantly different ($P = 0.05$) among all nutrient treatments. Treatment T1 with no nitrogen and no phosphorous reported the highest brown spot severity. The highest incidence of Whitehead was reported for T2 and T3 treatments. Peroxidase, phenylalanine ammonia lyase (PAL) and total phenols in rice leaves under different fertilizer treatments were quantified as defence related enzymes/chemicals responsible for pest and disease resistance. Interaction between treatment x sampling date was highly significant ($P<0.0001$) on all tested defence related compounds in rice leaves. Findings of the present study demonstrated the fertilizer effect on growth and plant health performances in rice and possibility of implementing EFTs for profitable and sustainable rice cultivation.

Keywords: Peroxidase, Phenylalanine ammonia lyase, Phenol, Brown spot disease, Whiteheads

This work was funded by the National Research Council of Sri Lanka (Grant no. TO 16-07).

[1]Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
[2]Rice Research and Development Institute, Bathalagoda, Ibbagamuwa

* devikadecosta@gmail.com

Evaluation of Effectiveness of Mycorrhizae Fungi on Growth of Potato (*Solanum tuberosum* L.) under Controlled Conditions

Jayawickrama K.W.P.R. and Rajapaksha R.M.C.P.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Potato is a major tuber crop grown in phosphorous (P) enriched fields in upcountry of Sri Lanka. Interactions between potato and arbuscular mycorrhizae fungi (AMF) were assessed by conducting a pot experiment using soils collected from six conventional fields. One potato seedling was uprooted from each pot after one month. The remaining seedling was uprooted after two weeks of adding recommended doses of N and K and ½ of P fertilizers (CF). Plant weights were reported. Root infection by AMF was assessed. Soils were analyzed for P fractions initially. Potential of AMF to mobilize reserved soil P was assessed by growing potato in 42 pots using a potato grown soil by imposing 14 treatments; CF + 11 inoculants (five AMF inoculants, one P Solubilizing bacterial inoculant (PSB), five duel inoculants comprising PSB and AMF), and three non-inoculated treatments. Plants were uprooted after 30 days and analyzed as described previously. Total P contents in six fields ranged from 1,897 to 3,352 mg/kgand 70-85% of P was found in the inorganic fraction. AMF hyphae and arbuscules infection remained <49 % and <25 %, respectively after one month and they were doubled after adding fertilizers. Negative correlations found between arbuscules percentage and, water and $NaHCO_3$ extractable P ($r>0.70$, $P<0.02$) imply that bioavailable P fractions of fields were high enough to suppress AMF. AMF inoculants increased plant growth and arbuscules infection significantly ($P<0.05$) over non-inoculated control added with CF or recommended P fertilizer. Inoculation of PSB alone did not increase plant growth or AMF infection significantly, but root growth was increased by 2 to7-fold when added along with four spore types of AMF. Results provide evidence that inoculation of AMF alone enhanced root infection and plant growth, despite reduced P fertilizer inputs. Enhanced root growth by four duel inoculants could lead to high yields.

Keywords: Arbuscular mycorrhizae fungi, Phosphorous, Phosphorous solubilizing bacteria, Potato

* chandir@pdn.ac.lk

Evaluation of New High Shade Tree Species (*Derris microphylla*) on Growth and Recovery after Pruning of Tea (*Camelia sinensis*)

Sampath W.N., Weerasinghe K.W.L.K.*, Wijerathna M.A.[1] and Pathiranage S.R.W.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tea is considered as a shade loving plant since it originated in an *Albizia* forest in Central Asia. Thus partial shading is essential for the sustainable production of tea bush. *Albizia molucana* is the most popular high shade tree species found in low country tea plantations; however, its short lifespan demand *Albizia* be replaced after every 8-10 years. Therefore shade trees implementation has become a high cost operation to plantations. *Derris microphylla* is a new shade tree species with higher lifespan hence this study was carried out to find suitability of the *Derris* as high shade tree species. Field was established in low country tea growing area in Rathanpura district, Houpe estate in Kahawatha plantation (WL1a / 30 m amsl / rainfall >3200 mm yr^{-1} / temperature 28°C). Seven shade treatments were replicated 3 times in a RCBD design. Treatments were consists with 3 different high shade tree species (*Albizzia*, *Derris* and *Casia*) and their different spacing. In the center of each plot (~0.25 ha), around 40 tea bushes were selected and considered as the middle of the plot where all data were collected. Nineteen (19) yield component parameters measured in *Derris microphylla* and *Cassia nodosa* shade systems were compared with *Albizia molucana.* Shoot girth, shoot weight, shoot height, mother leaf chlorophyll content and root starch content were considered as main growth parameters. All the data were analyzed using ANOVA procedure to determine the effects of shade system. The results revealed no significant difference among the different shade system ($\rho>0.05$) tested. Hence growth and health of tea cultivated under the shade of *Derris microphylla* found to be comparable with tea grown under *Albizia moluccan*a. Therefore, *Derris microphylla* (20 x 20 ft spacing) can be used as a promising alternative for *Albizia moluccana* in tea cultivations under low country tea growing conditions.

Keywords: *Albizia molucana*, *Cassia nodosa*, *Derris microphylla*, Shade tree, Shade system

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[1]Tea Research Institute, Low Country Regional Centre, Ratnapura

* lasanthaw@pdn.ac.lk

Evaluation of Production and Reproductive Performance of Crossbred Dairy Cattle in a Large Scale Semi Intensively Managed Farm in Coconut Triangle, Sri Lanka

Mohottala G.M.M.C. and Dematawewa C.M.B.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

A study was carried out to determine the factors affecting productive and reproductive performance of crossbred cattle raised under semi-intensive management system in Coconut triangle within IL-1 agro-ecological zone. A large scale Government farm, located in Kurunegala district, with crossbred cows of Jersey, Sahiwal, Australian Friesian Sahiwal (AFS) and Girolando sires was used for the study. Performance records of 157 cows in 6 parities were selected after screening for missing information. The traits studied were lactation yield (LY), lactation length (LL), age at first calving (AFC), number of services per conception (NSC), calving interval (CI), and calf birth weight (CBW). Analysis of variance procedure was carried out using crossbred genotype and parity of cow as fixed effects and Duncan's New Multiple Range Test was used for mean comparison. Mean performance values of LY, LL, AFC, NSC, CI and CBW of the farm were 1,182.5 litres, 258.5 days, 49.0 months, 1.3 services, 459.4 days and 18.9 kg, respectively. There was no significant effect of cow genotype on LL, NSC, CI or CBW ($P>0.05$). Girolando cross had significantly ($P<0.05$) lower LY (920.2 litres) compared with Jersey cross, Sahiwal cross, and AFS cross (1,251.4, 1,167.5, and 1,141.7 litres, respectively). Moreover, Girolando cross reported significantly higher AFC and higher BW in the farm compared with the other crosses ($P<0.05$). Parity had a significant effect on LY, LL, NSC and CI where sixth parity had the lowest LY, LL and CI values ($P<0.05$). First parity cows had lower NSC than others ($P<0.05$). Possibility for continued use of Girolando cross must be further investigated in the light of their poor performance exhibited. Improving management conditions to obtain better performance, particularly in older cows (>fifth parity), could improve the productivity of the farm as well as enable expression of true breed differences.

Keywords: Breeding policy, Calving interval, Crossbred cattle, Milk yield

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* mdematawewa@gmail.com

Evaluation of The Effect of Colour on Attraction of Pest Insect, Neutral Insect, and Natural Enemies to the Sticky Traps in Vegetable Eco-System

Piyasena M.A.R., Hemachandra K.S.* and Weligamage S.S.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The insect pest problem is one of the limitations of vegetable cultivation and integrated management of the insect pests is the recommended approach. Among non-chemical approaches, sticky traps have been suggested to manage small flying insects. The sticky traps catch the pests as well as beneficial arthropods including predators, parasitoids and neutral insects. The catch of beneficial and neutral insects is problematic; hence, requires an intervention. It was hypothesized that colour of the trap could be used to selectively trap the pest species; hence, this study was conducted with the objective of examining the effect of trap colour for the attraction of different insect groups: pest, beneficial, and neutral insects. The study was conducted in three vegetable fields at Kurunegala, Matale and Peradeniya. Five colours: yellow, blue, luminous green and white were used. The transparent trap was used as the control. The traps were set in the field for 24 hours. The insects caught in each trap were counted and identified as a pest, beneficial and neutral insects. The trap colour significantly affected on the catch; there was a significant variation of the total catch among trap colour (X^2 =107 df=4 $P<0.05$). Luminous green trap caught 29.1% of insects followed by yellow (22.0%), white (18.8%), blue (18.0%) and transparent (12.2%). When the catch was examined for taxonomic levels, more dipterans (40.7%) were caught in traps, and the majority of them was neutral (76.2%). The hymenopterans in the traps belong to the families Braconidae (8.8%), Ichneumonidae (5.1%), Trichogrammatidae (2.9%). When examined the ecological role, the blue colour traps caught a comparatively less number of neutral insects (29.1%) and beneficial insects (29.4%). Other traps caught a higher percentage of beneficial and neutral insects. The overall results suggest that the sticky traps should be used with caution in mass trapping of insect pests.

Keywords: Biodiversity, Diptera, Ecological-role, Monitoring, Order

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[1]Horticultural Crops Research and Development Institute, Department of Agriculture, Gannoruwa, Peradeniya

* kshema@pdn.ac.lk

Evaluation of the Performances of Bean Varieties under Insect Pest Infestation

Umesha B.G.S., Hemachandra K.S.* and Shyamalee H.A.P.A.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Common beans (*Phaseolus vulgaris* L.) are economically important vegetable crops grown in nearly all over the world to consume as fresh or processed. One of the production limitations is the insect attacks leading to crop loss. One of the strategies of managing insect pest infestation is the use of resistant varieties; hence, this study was conducted with the objective of assessing the performance of selected bean varieties/lines under natural insect pest infestation. HO 1, HO 2 and PB 151 breeding lines and Balangoda nil, Lanka butter and Keppetipola nil varieties were used in this study. Growth performance, severity and incidence of bean fly, bean leaf miner and legume pod borer infestation and yield were evaluated in each variety/lines. The pot experiment was laid as Completely Randomized Design with 10 replicates while field trial was laid as Randomized Complete Block Design with 3 blocks. The findings revealed that T2 (HO 2) grew with significantly high growth rate, 8.8 cm/week. It had 14.3% plant mortality, 34.8% of leaves with bean fly infestation, 44.7% of leaves with bean leaf miner infestation and 3116.7 g/plant yield. HO 2 is the best performing bean line. The lowest performance was recorded in T5 (Lanka butter). The recommended variety to Matara district (T6 – Keppetipola nil) exhibited a plant growth of 4.5 cm/week, 24.3% of plant mortality, 53.7% of leaves with bean fly infestation, 32.2% of leaves with bean leaf miner infestation and 600 g/plant yield. The study data suggest that HO 2 is the most suitable breeding line to promote as a home garden bean crop in Matara district.

Keywords: Bean fly, Bean leaf miner, Legume pod borer, Common bean, Growth performance

[1]Agricultural Research Station, Thelijjawila, Matara

* kshema@pdn.ac.lk

Exploring Phosphorus Mobilizing Capacity of Selected Grain Legumes in Limited Phosphorus Availability in Soil

Thennegedara T. G. R. M., Dissanayake D.M.S.B.* and Hettigedara H.M.P.T.K.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Phosphorus (P) is an essential macronutrient limiting plant growth and yield due to its poor availability in most soils. Use of alternative approaches to better utilize soil-P resources are important. Legumes have superior ability to mobilize part of the unavailable P into available forms. Therefore, the objective of the present study was to explore the dynamics of rhizosphere-P fractions of selected grain legumes and its influence on growth, P uptake, and yield under limited P availability. A pot experiment was carried out in a greenhouse with soybean [*Glycine max* (L.) Merr], cowpea [*Vigna unguiculata* (L.) Walp.], green gram [*Vigna radiata* (L.) Wilczek], and black gram (*Vigna mungo* L.) with two P fertilizer applications (without P application and with P fertilizer at Department of Agriculture recommendation). Most plant organs maintained similar dry weight and tissue-P concentration irrespective of the P level. All crops reduced their total plant-P uptake under low-P availability. However, this did not make any significant change in some yield parameters including number of pods per plant and number of seeds per pod. Soybean and mung bean had a greater P accumulation compared to cowpea and black gram under both P levels. In contrast, cowpea and black gram showed improved phosphorus use efficiency (PUE) than other two legumes. Available P concentration ($NaHCO_3$-P) in rhizosphere soil is greater than that in non-rhizosphere soil in soybean and cowpea whereas in mung bean and black gram cultivated under low-P availability, rhizosphere $NaHCO_3$-P was greatly decreased compared to non-rhizosphere soil. These findings suggest that the selected grain legumes could be cultivated under limited-P availability as they tend to adapt either through enhancing P uptake or increasing PUE.

Keywords: Grain legumes , P-Mobilization, Rhizosphere, P-uptake, P-use

[1]Field Crops Research & Development Institute, Mahailluppallama

* dissanayakauop@yahoo.com

Growth and Nitrogen Nutrition of Bush Bean (*Phaseolus vulgaris* L.) and Radish (*Raphanus sativas* L.) as Affected by Foliar Application of Urea

Kulathunga K.S.P. and Suriyagoda L.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Soil and foliar application of fertilizers are practised to provide required nutrients to high-value, fast-growing crops. Although numerous studies have investigated the impact of foliar urea application on growth of horticultural crops, inadequate information is available on the rate of foliar application in Sri Lanka. The experiment was conducted to study the growth and nitrogen (N) nutrition of radish (*Raphanus sativas* L.*)* and bush bean (*Phaseolus vulgaris* L.) when grown under different rates of soil and foliar application of urea. This experiment was laid out in a Randomized Complete Block Design with 24 treatment combinations and four replications. The treatment combinations included no N application (NO), recommended soil N application(SOIL100), reduced soil N applications of 75%, 50%, 25%, with substituting foliar applications (SOIL75, SOIL50, SOIL25, respectively), and as 100% foliar N application (SOIL0) under two mulching treatments; with and without mulch. Urea (1%) was applied as a foliar spray.There were no significant differences ($p>0.05$) in N of dried and fully expanded leaves, pods of bush bean, and fully expanded leaves and tuberous roots of radish among the N application treatments. Significant differences ($p<0.05$) were observed in plant height, total dry weight, length of the longest root in bush bean, and fresh weight of leaves and tuberous root of radish. The treatment without N (NO) showed the lowest values for all the parameters. There was a significant difference ($p<0.05$) between NO and SOIL50 for all the growth parameters. The combination of 50% of soil application with 50% of foliar application is the most suitable practice of urea application for higher yields in radish and bush beans.

Keywords: Bush bean, Foliar application, Radish, Soil application, Urea

* lalith.suriyagoda@gmail.com

Growth and Nutrition of Rice (*Oryza sativa* L.) when Grown in Cadmium Contaminated Soil with Different Water Management and Soil Amendments

Premasinghe S.A.C.J., Suriyagoda L.* and Ariyaratne M.
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Water scarcity and high soil cadmium (Cd) contamination are some of the major challenges for global food security including rice (*Oryza sativa* L.). Biochar has been used to reduce heavy metal uptake by rice plants. Moreover, the effectiveness of biochar in reducing Cd uptake by rice may be affected by water availability. The current study assessed this interaction. The experiment was carried out as a three-factor factorial experiment (i.e., soil contaminated with and without Cd, alternate-wetting and drying (AWD) and flooded (FD) soil condition, and biochar and paddy husk addition as soil amendments). The FD soil condition increased shoot dry weight, Na and Mn in shoots. Plant height and greenness of flag leaf were reduced with Cd. Addition of paddy husk reduced Cd in rice shoot (0.03 μg g^{-1}) than that observed in biochar added (0.08 μg g^{-1}) and control soil (0.05 μg g^{-1}). Shoot Fe in Cd treated soil was higher (139.85 μg g^{-1}) than that in untreated soil (76.67 μg g^{-1}). Plant shoot K was higher with AWD soil condition. Rice crop nutrition and soil nutrient dynamics were affected by high soil Cd. Long term incorporation of paddy husk is suitable to ameliorate Cd toxicity in affected soils. Soil moisture availability did not affect the accumulation of Cd in rice shoot.

Keywords: Biochar, Cadmium, Deficit irrigation, Rice

* lalith.suriyagoda@gmail.com

Identification of Optimum Concentration of 17-α-Methyltestosterone Hormone on Sex Reversal of Guppy

Jayasinghe A.M.K., Athauda A.R.S.B.* and Mudalige A.R.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was conducted to determine the optimum 17-α-Methyltestosterone hormone concentration required to produce phenotypically sex reversed guppy among different concentrations of 10, 20, 30 and 40 mg/kg feed used as treatments along with the control. Each treatment and the control had 3 replicates with 70 number of fry reared in glass tanks until 75 days of the experimental period. Hormone incorporated powdered feed was fed to fish which was prepared using *Prima naught* fish feed (800 g), fish meal (200 g), and vitamin-mineral mixture (10 g) for preparation of 1 kg of experimental feed. The hormone was mixed with feed by using the ethanol spray method. Treatment feeds were given during the first 21 days followed by the control feed for rest of the period. At the end, morphological features were assessed in each fish. The survival rate showed an inverse relationship with hormone concentration while no significant difference ($p>0.05$) among different levels of hormone fed groups. Bodyweight gain and masculinization were increased with the increment of the concentration with significant differences among each other ($P<0.05$). There was no significant difference in color intensity of guppy among different 17-α-Methyltestosterone hormone fed groups ($P>0.05$). However, significantly higher color intensities were observed in guppy in treatment groups than the control ($P<0.05$) while the fish under 40 mg/kg treatment showed the highest body weight gain and masculinization than others. There was no significant difference in survival rate between 30 mg/kg and 40 mg/kg hormone-treated groups ($P>0.05$). The findings of this study showed that 17-α-Methyltestosterone concentration of 30 mg/kg can be used as the optimum hormone concentration for sex reversal of guppy with a minimum cost.

Keywords: Guppy, *Poecilia reticulata*, 17-α-Methyltestosterone, Sex reversal

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[1]National Aquaculture Development Authority Dambulla Center, Dambulla

* sbathauda@pdn.ac.lk

Identification of Suitable Weed Management Options for Ultra-Short Age Rice Variety LD253

Jayasinghe.W.T.B.P.K., Rankoth L.M.*, Marambe B. and Illangakoon T.K.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rice (*Oryza sativa* L.) is the main food crop of more than half of the world population including Sri Lanka. Many rice varieties including several ultra-short age rice varieties are grown in Sri Lanka. Invasion of weeds is one the major problems in direct-seeded rice (DSR) production across all rice growing agro-ecologies. However, the suitability of seeding rates and weed management strategies to optimize the yield of ultra-short age rice variety Ld253 have not yet been tested. To fill this knowledge gap, the present research was conducted at the Rice Research and Development Institute of the Department of Agriculture located in Ibbagamuwa (IL1b, North Western Province), Sri Lanka during the *Maha* season (December 2019–March 2020). A field experiment consisting of two seed rates of Ld253; 100 kg ha^{-1} and 150 kg ha^{-1}, and four weed control methods; Early emergence herbicide (EE), Post emergence herbicides (PE), No weeding (NW) and Complete weeding (CW), in a two-factor factorial Randomized Complete Block design (RCBD) with three replicates was conducted. Considering the seed rate, there was no significant difference between 100 and 150 kg ha^{-1} on weed count, tiller count and yield. However, the EE and PE herbicides with 100 kg ha^{-1} showed numerically lower tiller counts compared to 150 kg ha^{-1} at 6 weeks after planting (WAP). The effect of EE herbicide on broad leaf weed count was significantly different than that of PE herbicide at 100 kg ha^{-1} seed rate where PE showed the better weed control. However, the tested seed rates and the weed control methods did not show any significant effect on the final yield of the crop. Thus, further research on different seed rates and other available weedicides may be required to identify better weed control measures for the Ld253 rice variety in Sri Lanka.

Keywords: Early emergence herbicides, Ld253, post emergence herbicides, ultra-short age rice varieties

[1]Rice Research and Development Institute, Bathalagoda, Ibbagamuwa

* lalithrankoth@gmail.com

Impact of Different Controlled Released and Stabilized Nitrogen Fertilizers on Potato (*Solanum tuberosum* L. cv. 'Granola') in Nuwara Eliya, Sri Lanka

Dilan A.J.R.T., Nissanka S.P.* and Abeytilakarathna P.D.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Groundwater pollution due to excessive use of chemicals in agriculture fields is a major concern in the upcountry, Sri Lanka. Potato cultivation is the key contributor to this problem in Nuwara-Eliya and Badulla Districts. A pot experiment was conducted at Agricultural Research Station, Sitha-Eliya, Sri Lanka, to examine the effect of different nitrogen fertilizer sources, including stabilized urea and different rates on growth, tuber yield, and also to examine the agronomic Nitrogen Use Efficiency (NUE) of potato. The experiment consisted of seven treatments including zero nitrogen (control: T1), DOA recommendation (T2:150 kg N/ha), farmer practice (T3:220 kg N/ha), farmer practice + 10% nitrogen stabilizer (DCD: Dicyandiamide and NBPT: N-(n-butyl) thiophosphoric triamide) (T4), 75% farmer practice + 10% nitrogen stabilizer (T5), Yara® [116 kg N/ha] fertilizer (T6) and Yara® fertilizer + 10% nitrogen stabilizer (T7). The T6 and T7 treatments showed significant differences in plant height, tuber number, tuber yield while reducing the cumulative total N amount in leachate ($p<0.05$). The highest yield was recorded in Yara® fertilizer + 10% nitrogen stabilizer (T7), which was 26.2 t/ha and giving a 36% higher yield than the T2. The highest agronomic N use efficiency (AE_N) was reported in T7, and it was 132 kg tuber yield per kg of N applied compared to the control. Results showed that the application of a higher dose of N in the basal dressing increased N leaching and acidification of leachate, which exceeded the NO_3-N concentration in the leachate well-above the WHO recommended level in drinking water. Nitrogen stabilizers can reduce nitrogen accumulation in groundwater by manipulating the activity of urease enzyme and nitrification while increasing yield potentials and providing significant environmental, economic, and health benefits.

Keywords: Agronomic efficiency of nitrogen, DCD, NBPT, Potato, Urea

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[1]Department of Agriculture, Agricultural Research Station, Seetha Eliya

* spn@pdn.ac.lk

Impact of Different Wavelengths on the Growth, Leaf Anatomy and Yield of Rice (*Oryza sativa* L).

Samarasinghe S.A.I.L.N. and Ariyaratne M.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Different wavelengths within the photosynthetically active radiation (PAR) influence differently for plant growth. In this experiment, we investigated the effect of red light (628 nm), blue light (445 nm), and their combination on growth, leaf anatomy, and yield of BG300 and BG251 rice varieties. Plants were exposed to four light treatments; no additional light (L1), red light (L2), blue light (L3), and red and blue combination (L4). All treatments except the control had similar light intensities (50 µmol/m^2/s). Plants were exposed to treatments from 6.00 pm to 10.00 pm. In BG300, shoot dry weight and chlorophyll content were significantly higher in L2, L3, and L4 treatments in comparison to L1. Highest root dry weight was observed under blue LED light and it was significantly different from other treatments. L4 had the lowest root depth and it was significantly lower than the other treatments. Plant height and number of tillers did not demonstrate a significant difference among the treatments in BG300. In BG251, plant height, root depth, root dry weight and chlorophyll content (SPAD meter value) were significantly higher in L2, L3 and L4 treatments than in L1. Highest shoot dry weight and hundred grain weight were observed under blue LED light. Early panicle initiation was observed in L1 and L3 treatments and it was significantly different from L2 and L4. There was no significant difference in leaf thickness and number of tillers. Blue light had the highest yield per plant (16.14 ± 5.24 g $plant^{-1}$) and it was significantly different from other treatments.

Keywords: Growth, Light quality, Rice (*Oryza sativa* L.), Wave length, Yield

* mariyaratne@yahoo.com

Improving Productivity of Stassen Bio Tea Garden by Adopting Better Management Practices

Sivaruban N. and Hitinayake H.M.G.S.B.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

A study was conducted to examine the effect of natural foliar sprays, compost and shade on tea yield and soil nutrients. In the first experiment, four natural foliar sprays; *Gliricidia* leaf extract, wild sunflower leaf extract, cow dung and urine mixture and vermiwash was evaluated against two levels of compost (1 kg and 2 kg per tea bush). Pure water was used as control. Treatments were arranged in randomized complete block design with three replicates. In experiment two, the performance of tea plants was evaluated under two natural light levels (133.26 Wm^{-2} and 339.7 Wm^{-2}). Split plot design was used in experiment 2. The research studies were conducted at a seedling tea field in the Stassen Bio Tea Garden. Yields of each plot and soil parameters were measured before applying the treatments. Greenleaf yield, total plucking points, number and colour of active buds were measured in the weekly interval. Changes in major soil nutrients and organic matter content were also evaluated during the experiment. Results in the first experiment revealed that foliar application significantly increases the leaf weight, the number of plucking points and leaf colour whereas the number of active and banji buds were not significantly different. Effect of compost on yield was not significant during the research period. In compost applied fields significant improvement of Potassium was recorded in the subsoil whereas it was not significant for Nitrogen and Phosphorous. Cow dung + urine mixture and *Gliricidia* extract showed the highest fresh yield, leaf colour, and plucking points. Cow urine mixture and 2 kg of compost was the best treatment combination among other treatments. The second experiment revealed that the influence of light levels on growth parameters and soil Nitrogen and Phosphorous were not significant. Further, it showed that organic matter content was higher under the low light level.

Keywords: BioTea garden, Compost, Natural foliar sprays, Organic tea land management

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* gaminih@pdn.ac.lk

Molecular and Biochemical Characterization of a New Hybrid Population of *Camellia sinensis*

Rathiverni R., Ranatunga M.A.B.[1], Edirisinghe E.N.U.[2] and Jayawardana N.U.*
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Caffeine is a purine alkaloid present in *Camellia sinensis* (L.) O. Kuntze. Although caffeine has proven health benefits, excessive intake causes negative effects. In this study, development of low caffeine containing tea cultivars has been attempted by performing intra-specific hybridization between low and high caffeine containing parents, PBGT41 and TRI3055 respectively. Caffeine and other five major metabolites *viz.* epicatechin (EC), epicatechin gallate (ECg), epigallocatechin (EGC), epigallocatechin gallate (EGCg) and catechin (C) of 16 accessions along with parents were analyzed using High-Performance Liquid Chromatography (HPLC) following ISO protocols. Caffeine content in the progeny ranged between 13.42±0.20 mg/g and 24.01±0.06 mg/g with a mean value of 18.37±3.79 mg/g. Four accessions *viz*. 627, 631, 635, and 546 of the progeny were reported lower caffeine content than the low caffeine containing parent, PBGT41. Accession 635 reported the lowest value of 13.42±0.20 mg/g. Identified four low caffeine containing accessions could be further evaluated for suitability as potential tea cultivars for producing caffeine-less tea. The most abundant catechin, EGCg ranged from 27.56±14.4 mg/g to 73.56±14.4 mg/g. Further, studies were performed to ascertain caffeine-less trait in the hybrid progeny using a newly developed 'CafLess-TCS1' molecular marker to facilitate early screening. Genomic DNA of 127 individuals of the progeny was extracted. The Polymerase Chain Reaction conditions for CafLess-TCS1 primer have been optimized to obtain maximum specificity and yield. The study will be continued to explore the possibility of using CafLess-TCS1 as an effective DNA marker for identifying caffeine-less genotypes in the early stages of tea breeding programme.

Keywords: Biochemical characterization, Caffeine-less, CafLess-TCS1 marker

This research was funded by the Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka.

[1]Plant Breeding Division, Tea Research Institute of Sri Lanka, Talawakelle
[2]Biochemistry Division, Tea Research Institute of Sri Lanka, Talawakelle
* nuj@pdn.ac.lk

Morphological and Molecular Characterization of Selected *Aloe* Germplasm in Sri Lanka

Alahakoon A.M.P.D., Jayawardana N.U.* and Bandaranayaka P.C.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Aloe vera belongs to family Aloaceae and widely used in drug and cosmetic industry. Recently it has gained attention as a commercial crop. However, there is limited literature on crop improvement attempts. Thus the current study assessed the morphological and genetic diversity of selected *Aloe* germplasm in Sri Lanka. Fifty five *Aloe* accessions including the commercially grown were collected from 18 districts, grew under controlled environmental conditions and assessed with a morphological descriptor developed. The Principal component analysis (PCA) conducted with 16 morphological traits revealed that the first 5 principal components (PCs) accounted for 95.5% of the total variation. The traits such as leaf apex shape, tip spine arrangement, spine stiffness, leaf width, fresh weight and gel weight significantly contributed to the variation. The correlation analysis showed a significant correlation between the gel yield percentage with leaf apex shape, tip spine arrangement and spots density. The cluster analysis resulted 3 main clusters grouping the commercial accession into a separate cluster. One month old suckers of 37 *Aloe* accessions were assessed using 6 quantitative traits. The PCA revealed that the first 2 PCs accounted for 79.97% of the total variation with significant contribution of leaf fresh weight and thickness, suggesting the possibility of utilizing such traits for selecting superior planting material. To assess the species level diversity, 5 morphologically distinct *Aloe* accessions including the commercial accession were evaluated using universally accepted chloroplast DNA regions, matk and trnH. The DNA sequencing analysis suggests the presence of at least 3 *Aloe* species. To assess the within species diversity of *A.vera*, representative accessions were evaluated with 7 Inter Simple Sequence Repeat regions (ISSR). The analysis revealed a considerable genetic variation among individuals. These findings suggest the importance of selecting superior germplasm for achieving expected quality and quantity of yield in commercial *A. vera* cultivations.

Keywords: *Aloe vera*, chloroplast DNA, ISSR markers, plant descriptor

This work was funded by Agricultural Biotechnology Center, Faculty of Agriculture, University of Peradeniya.

[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* nuj@pdn.ac.lk

Performance Evaluation and Heritability Estimation for Economic Traits of Dairy Cattle under Large Scale Farming in Kurunegala District, Sri Lanka

Senarathna V.D. and Dematawewa C.M.B.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The objectives of this study were to determine the effects of genotype and parity on production and reproductive performance of crossbred cattle reared under large scale semi intensive conditions in Kurunegala district, and to estimate heritability values of those traits. Performance records of 153 crossbred cows of Australian Friesian Sahiwal (AFS), Jersey, and Sahiwal origin from a randomly selected major state farm were used for the analysis. Lactation length (LL), lactation milk yield (LY), number of services per conception (SC), age at first calving (AFC), calving interval (CI) and calf birth weight (CBW) were considered as economic traits. ANOVA procedure was used with Duncan's New Multiple Range Test for mean comparison. Fixed effects included genotype and parity of cow, birth type (normal, stillbirth, abortion; for CI and CBW) and service sire genotype (for SC and CBW). Half sib analysis was performed for heritability estimation on the above traits. Herd means for LL, LY, SC, AFC, CI and CBW were 277.3±4.09 days, 1774.1±41.83 kg, 1.53±0.04, months, 42.2±0.63 months, 404.52±7.09 days, and 19.61±0.09 kg, respectively. There were no significant differences among the genotypes of cows for any of the traits ($P>0.05$). However, AFS sires reported significantly higher ($P<0.05$) SC (1.84) and CBW (19.98 kg) than Jersey sires (1.39 and 19.26 kg, respectively). Seventh parity cows had significantly lower LL and LY than mature cows ($P<0.05$). Chi square analysis found that birth type was not significantly associated with cow genotype, sex of calf or parity of cow ($P>0.05$). However, LL of cows subsequent to stillbirths was significantly shorter than those after abortions ($P<0.05$). Heritability values for CBW, CI, LL, and LY were 0.072, 0.114, 0.245, and 0.619, respectively. Greater heritability estimates for production traits revealed the possibility for within herd genetic selection for milk yield concurrently with upgrading and improvement of management standards.

Keywords: Crossbred, Genetic parameters, Livestock, Milk yield, Reproduction

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* mdematawewa@gmail.com

Phenotypic Plastic Responses in Morphophysiological Traits of Three *Plectranthus scutellarioides* (L.) R. Br (coleus) Varieties in Response to a Light Gradient Continuum

Kodithuwakkuge V.N., Benaragama C.K.* and Krishnarajah S.A.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

An experiment was carried out to evaluate the phenotypic plastic responses in morphophysiological traits of three *Plectranthus scutellarioides* (L.) R. Br (coleus) in response to alight gradient continuum. "Alabama sunset", "Velvet red" and "Finger paint" varieties were exposed to 0, 40, 50 and 70% shade levels as two-factor factorial Completely Randomized Design. The changes in morphological and physiological traits were recorded. The results revealed that shade had a significant effect on almost all parameters. The highest leaf area, the highest specific leaf area and maximum plant height were observed under 70% shade. Highest chlorophyll content was observed under 70% shade and the highest anthocyanin content was observed under 0% shade. Maximum quantum efficiency and the highest Performance Index (PI) were observed under 70% shade. Colours of the multicoloured leaves also changed with time under different shade levels. Redness and brightness of red colour increased in leaves under 0% shade. The red colour was suppressed and the brightness of green colour increased under high shades with time. The highest Phenotypic Plasticity Index (PPI) values were recorded in anthocyanin content, chlorophyll content, leaf area and specific leaf area showing the importance of these traits as adaptive traits. Plant height, single leaf weight, number of leaves and number of branches recorded the lowest PPI values being more rigid morphological traits in these varieties. Overall, the light gradient affected the overall foliage quality of selected *Plectranthus scutellarioides* (L.) R. Br varieties.

Keywords: *Plectranthus scutellarioides* (L.) R. Br, Quantum efficiencies, Performance index, Specific leaf area, Phenotypic plasticity index

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[1]Department of National Botanic Gardens, Royal Botanical Garden, Peradeniya.

* chalindab@gmail.com

Phosphorus Nutrition Dynamics of Mung Bean to Moisture and Phosphorus Limited Conditions during Reproductive Growth

Abeysinghe A.H.M.N.P., Gunathilaka W.M.N.D.[1], Weerasinghe K.W.L.K. and Dissanayake D.M.S.B.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Phosphorus (P) deficiency and drought stress are significant yield-limiting factors in many cropping systems worldwide. Mung bean (*Vigna radiata* L. Wilczek) is recommended to cultivate as a mid-season crop in paddy fields by the Department of Agriculture (DoA), Sri Lanka. This experiment was conducted to investigate the growth performance and P-nutrition dynamics of mung bean in response to moisture and P co-limitation. Mung bean varieties MI5 and MI6 were grown in pots separately under two P levels (without and with P, at DoA recommendation) and two moisture levels (well-watered, and water stress imposed with the onset of flowering). Plant growth, organ-specific P accumulation, and yield parameters were measured. The water stress coupled with low-P availability in soil remarkably reduced biomass formation, plant P uptake, and the yield of both varieties. Under well-watered condition with P application, all plant organs recorded the highest P concentration. MI6 had the ability to acquire more P than MI5 when both varieties are cultivated without external P supply. The P use efficiency (PUE) of the two varieties increased under moisture and P co-limitation. Across all treatment combinations, MI6 had the highest PUE under imposed water stress condition without P application, and also produced greater pod dry weight compared to MI5 in low-P soil. This pattern was evident for other yield parameters, *i.e.* number of pods per plant, pod length, and number of seeds per pod, particularly under well-watered condition. Results clearly demonstrated that co-occurrence of P-deficiency and moisture stress could bring significant yield reduction of mung bean. MI6 is a better adapted variety compared to MI5 under two stresses, which are commonly prevailing in farmer fields.

Keywords: Mung bean, phosphorus-deficiency, water stress, yield parameters

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[1]Grain Legume and Oil Crop Research and Development Centre, Department of Agriculture, Angunakolapellasa

* dissanayakauop@yahoo.com

Potential of Selected Maize and Sorghum Varieties Cultivated During *Maha* Season in the Dry Zone for Dairy Cattle Feeding

Jagoda S.D., Kumara Mahipala M.B.P.*, Weerasinghe W.M.P.B.[1] and Senanayake R.L.[2]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The potential of selected maize (Badhra, MI Hybrid-1, MI Hybrid-2, Jet-999, Pacific-339) and sorghum (Sugargraze, MI Sweet sorghum) varieties cultivated during *Maha* season (November – March 2020) in the Dry zone was assessed. Forages were cultivated at 2 plant densities (High density; maize at 30×45 cm and sorghum at 30×15 cm, Low density; maize and sorghum 30×60 cm) on reddish brown earth soils at the Field Crop Research and Development Institute, Mahaillupallama. Maize and sorghum were harvested at 50% silking and flowering stage, respectively. Leaf number, leaf area and fresh weight were measured. Leaf area index (LAI), fresh matter yield (FMY) and dry matter yield (DMY), composition, in-vitro organic matter digestibility (OMD) and metabolizable energy (ME) content were determined. Forage age at maturity associated ($P<0.05$) with variety. Sugargraze matured first which was followed by maize varieties. MI sweet sorghum matured last. Plant height associated ($P<0.05$) with variety and variety & density interaction. Variety, density and variety & density interaction affected ($P<0.05$) on LAI, FMY, DMY and organic matter, ash & acid detergent fiber (ADF) contents. Greater LAI occurred at high density resulted greater FMY and DMY. MI sweet sorghum at high density had the highest LAI, FMY and DMY. Crude protein (CP), neutral detergent fiber (NDF) & ME contents and OMD associated ($P<0.05$) with forage variety. Pacific-339 had the highest CP content resulting the highest OMD and ME. Variety, density and variety & density interaction affected ($P<0.05$) on CP, digestible organic matter (DOM) and ME yield per hectare. Therefore, MI sweet sorghum at high density had the highest CP, DOM and ME yield. Locally produced MI sweet sorghum (high density) and imported maize variety Pacific-339 have greater potential to cultivate during *Maha* season in the Dry zone in order to include in medium and high yielding dairy cow rations, respectively.

Keywords: Yield, Nutrient and ME content, Organic matter digestibility

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[1]Division of Pasture and Fodder Crops, Veterinary Research Institute, Gannoruwa, Peradeniya

[2]Field Crops Research & Development Institute, Mahailluppallama

* pmahi@pdn.ac.lk

Pre-slaughter Stress Conditions, Efficacy of Electrical Water Bath Stunning, Carcass Quality and Meat Quality of Broiler Chickens Reared in Opened Houses and Closed Houses

Kavinda M.H.D., Bandara R.M.A.S.[1], Nishshanka N.A.K.C.[2], Adikari A.J.M.A.D.[2], Chathuranga T.G.S.[2] and Samarakone T.S.[*]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

It is important to avoid pain and suffering during the process of slaughter to ensure welfare of animals. This study was conducted to identify pre-slaughter stress, efficacy of electrical water bath stunning (voltage=20-30V, current =200-400mA, frequency=300Hz), carcass and meat quality of broiler chickens (Body wt: 1.9±0.1kg, 35±2 days old) reared in two housing systems (closed housed: N=49 birds; opened housed: N=55 birds). Birds were rested for 30 minutes before slaughter at the lairage. Closed housed birds showed severe panting ($P<0.05$) at the lairage before slaughter. Observed reflexes and behaviours to detect the efficacy of water bath stunning were not different between the two groups of birds. Shorter time to loss of jaw tone and pupillary light reflex were observed with the opened house birds (14±1s and 16±1s respectively) than with the closed house birds (29±1s and 24±1s respectively) indicating shorter time to brain death in opened house birds after neck cutting. In overall, stunned birds in both the housing systems started to regain consciousness within 3 minutes and fully recovered within 5 minutes. Hemorrhages in the breast and drumsticks were observed in nearly 50% of closed house birds and it was significantly higher than the birds reared in opened houses ($P<0.05$). However, nearly 50% of opened housed birds had blood spots on their wings ($P<0.05$) while it was lower (nearly 20%) with closed housed birds ($P<0.05$). Ultimate pH and water holding capacity were significantly higher in the opened housed birds ($P<0.05$) than those of closed house birds. There was no difference ($P>0.05$) in meat color values between the two groups. This study revealed that closed housed birds were more stressed prior to slaughter and resulted lower quality meat with hemorrhages than the birds reared in opened houses. There was no effect of housing system on efficacy of water bath stunning.

Keywords: Welfare of animals, Housing systems, Behaviour, Electrical water bath stunning, Hemorrhages

[1]Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka
[2]New Anthoney's Farms (Pvt) Ltd. Hanwella
* thusiths@pdn.ac.lk

Rhizosphere Nutrient Availability and Growth Response of Soybean as Affected by Biochar Application

Neththasinghe N.A.S.A., Karunarathna A.K.[1] **and Dissanayake D.M.S.B.***
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Biochar application in agricultural soils can be highly beneficial to plant productivity in numerous ways. Rhizosphere nutrient dynamics and its relation to nutrient uptake and plant productivity under biochar amendment remain unclear. Therefore, the aim of the present study was to investigate the impact of gliricidia biochar application and incubation condition on beneficial effects of soybean (*Glycine max* L.) plant. A pot experiment was conducted with two biochar applications (with and without biochar) and two incubation conditions (with and without incubation) in a glasshouse. The impact of biochar on nutrient availability of rhizosphere and non-rhizosphere soils, plant growth, and yield were measured. A separate soil column leaching experiment was conducted to test the nutrient retention ability and other chemical properties of soil once amended with biochar. Biochar application and incubation treatment did not cause a significant impact on biomass accumulation of many plant organs and some of the yield component of soybean except the pod dry weight. Irrespective of the incubation condition, biochar application made a significant increase in pod dry weight. There was a tendency of increasing concentrations of nitrogen (N), phosphorus (P), and potassium (K) both in rhizosphere and non-rhizosphere soils when plants are grown under biochar amendment. Concentrations of those nutrients were lower in rhizosphere soil compared to non-rhizosphere soil. Total nutrient uptake by soybean plant greatly increased under biochar amendment compared with the plants grown without biochar. When incubation is not done, soybean plant increased its P and K uptake respectively by 52% and 48% under biochar amendment compared to those without biochar. With incubation, the relevant increases were 42% and 32% respectively. The results from soil column leaching experiment suggest that the application of biochar in planting media could be an effective way to retain soil N through reducing the leaching.

Keywords: Biochar, incubation, rhizosphere, soybean

[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya

* dissanayakauop@yahoo.com

Screening of a Diverse Range of Rice (*Oryza sativa* L.) Genotypes for Drought Tolerance

Wickramasinghe M. S. K., Abeysiriwardena D.S. De Z[1], Senadheera S.A.D.P.[2] and De Costa W.A.J.M.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Drought is the major abiotic stress affecting rice production in Sri Lanka. Development of drought-tolerant rice varieties is the most feasible option for minimizing rice yield losses due to drought. The objective of this field experiment, conducted at the CIC farm, Pelwehera, was to screen a diverse panel of rice genotypes with known genomic information and identify genotypes with characters contributing to drought tolerance. The treatment structure was a two-factor factorial in a split-plot design with two water treatments (well-watered and water-stressed) as the main-plot factor and 200 genotypes as the sub-plot factor. The 200 genotypes contained 47 fully-sequenced Sri Lankan genotypes and 116 genotypes in which 6000 genomic locations have been sequenced. In the water-stressed treatment, grown under a rainshelter, water stress was imposed by withholding irrigation from the late-vegetative stage onwards, while the well-watered treatment was irrigated continuously. The water-stressed treatment showed 57% and 77% depletion of soil moisture relative to the well-watered treatment at 10 and 20 days after commencement water stress. Leaf temperature (LT), leaf relative water content (RWC), area of the youngest fully-expanded leaf (LA), plant height (HT) and tiller number (TIL) were used as criteria for screening genotypes for drought tolerance. All characters except tiller number showed highly-significant ($P<0.0001$) genotype × water regime interaction. Highly-significant ($P<0.0001$) genotypic variation was shown in all characters in both water regimes. Based on the capacity to maintain a lower LT, higher RWC, LA, HT and TIL under stress, genotypes in the top 3%, 7.5% and 15% of the population were identified as highly-tolerant, tolerant and moderately-tolerant. Based on tolerance levels for multiple characters, 16, 25 and 39 genotypes respectively were identified as highly-tolerant, tolerant and moderately-tolerant. This classification showed a highly-significant positive correlation (r_s=0.216; P=0.0019; n=203) with the classification based on visual observation of plant performance at maturity.

Keywords: drought tolerance, leaf relative water content, leaf temperature, soil moisture depletion

[1]CIC Agri Bussiness Center

[2]Department of Botany, Open University, Sri Lanka

* janendrad@gmail.com

Status of Leafy Vegetable Farming and Selection of Suitable Insecticides for the Control of Insect Pests of Leafy Vegetables

Chularathna H.A.M., Prabath Nishantha K.M.D.W.[1] **and Hemachandra K.S.***
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Market demand for leafy vegetables remains high since it is an essential component in a balanced diet. One of the constraints of leafy vegetable production is the pest incidences and the frequent use of insecticides. Insecticide application is associated with many health and environmental issues; hence, the objective of this study was to assess the agrochemical usage in leafy vegetable cultivations in Gampaha and Puttalam districts through a farmer survey and to evaluate the efficacy of selected insecticides namely flonicamid 25% SC, pyrifluquinazon 20% SC, and azadirachtin A 7.5 g/L EC in controlling insect pests: *Halticus minutus* and *Amrasca* spp. of leafy vegetables. Treatments were laid out as in Randomized Complete Block Design with four blocks and the field was sprayed once. Effectiveness of insecticides was calculated as per the suppression of insect population. Direct field observations and responses to a pre-tested structured questionnaire showed that there were two groups of farmers: small scale and large scale and 77.1% of them use inorganic pesticides in leafy vegetable cultivation which includes 15 brands of insecticides and 5 brands of fungicides. Pesticide dealers' advice has been the basis for pesticide selection for majority of the farmers. Use of label information by commercial growers was poor. Recommended dose was applied by 35% farmers and pre-harvest interval was respected by only 10% of farmers. Poultry manure was heavily used as a fertilizer compared to synthetic fertilizers. There was a significant difference in efficacy among tested insecticides in controlling both *Amrasca* sp. and *H. minutus*. In comparison to DOA recommended insecticides, Azadirachtin A 7.5 g/L EC at 4 ml/L was the most suitable insecticide for the control of *Amrasca* spp. Findings of the present study are helpful to develop an eco-friendly and sustainable pest management system in leafy vegetable farming.

Keywords: Agrochemical , *Amrasca* spp, *Halticus minutus*, Pre-tested questionnaire

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[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya

* kshema@pdn.ac.lk

The Effect of Media Additives on *In-vitro* Growth and Assessment of the Genetic Diversity of Seed Propagated Planting Materials of *Vanda* Orchids

Pathirana P.B.G., Bandara D.C.*, Bandaranayaka P.C.G.[1] and Herath H.M.I.[2]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The study aimed in developing an efficient and effective protocol for *in-vitro* growth of seed propagated *Vanda* orchids together with the assessment of the genetic diversity of the progeny. Hence, the effects of three media additives namely carrot, banana and king coconut water prepared at different concentrations were examined when used with full, half and quarter strength of 2 basal media, Murashige and Skoog (MS) and Knudson C (KnC) for the successful growth of *in-vitro* propagatedseedlings of V. 2205**(Vanda* Mimi Palmer * *Vanda coerulea*). Carrot and banana were used at concentrations 0, 75 g/L and 150 g/L and king coconut water was used at 0, 150 mL/L and 300 mL/Lwith each level of the basal media separately. Four months old *Vanda* seedlings established in a Completely Randomized Design, maintained for 6 weeks were observed for the increments in leaf number, root number, shoot number and plant height per seedling at the end of subculture. Interestingly, the growth of seedlings treated with the additives was higher compared with no additives. Further, the growth performance was higher when the full MS was supplemented with 150 g/L carrot and full KnC with 75 g/L banana. To assess the genetic variability among seed propagated plants, 5 morphologically similar and 5 morphologically different plants were selected randomly from different treatment combinations. The leaf DNA extracted using CTAB method was assessed with 3 Inter simple sequence repeats (ISSR) regions, UBC 808, UBC 834 and UBC 888. Of the total of 34 loci observed, 91% were polymorphic. The UPGMA dendrogram generated with binary data clustered both morphologically similar and dissimilar individuals together with no clear pattern. The current findings strongly suggest that the genetic diversity of seed cultured progeny should be assessed and considered in any breeding program or *in-vitro* protocol even if they look alike.

Keywords: seed culture, genetic diversity, media additives, ISSR

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[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

[2]Department of National Botanic Gardens, Royal Botanical Garden, Peradeniya.

* deepthib@pdn.ac.lk

Therapeutic Effect of *Allium sativum*, *Trigonella foenum-graecum* and *Momordica charantia* for Bovine Mastitis

Amarawansha R.M.K.P., Jinadasa H.R.N.[1], Rajapakse R.P.V.J.[1], Jayasinghe U.L.B.[2] and Wijayagunawardane M.P.B.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Bovine mastitis is an inflammation of mammary gland tissues and one of most economically important diseases affecting global dairy industry. The objective of the present study was to evaluate the therapeutic potential of fresh juice extract (Swarasa), organic (methanol) extract and aqueous extract of bulbs of *Allium sativum*, fruits of *Momordica charantia* and seeds of *Trigonella foenum-graecum* for bovine mastitis. Assessment of antibacterial propertiesof 3 different extracts from selected plants was accomplished *in-vitro* against pathogens of *Staphylococcus aureus* (ATCC 25923), *Escherichia coli* (ATCC 25922) and *Pseudomonas aeruginosa* (ATCC 27353) by well diffusion method, while the most powerful plant and type of extract with significantly different effect were identified ($P<0.05$). MTT (3-(4,5-dimethylthiazol-2-yl)-2,5diphenyltetrazolium bromide) assay was used to identify the non-cytotoxic concentration of efficacious extract type of most powerful plant for further characterization and applications. The results of the current study demonstrated that, fresh juice extract was the comparatively best type of plant extract than aqueous and methanol extracts, which did not show any considerable inhibitory effect against tested pathogens ($P<0.05$). Fresh juice extract of *A. sativum* showed the towering inhibitory effect against *S. aureus, E.coli* and *P. aeruginosa* while combinations of *A. sativum* with *M. charantia and A. sativum* with *T. foenum-graecum* showed towering synergistic inhibitory effect against *S. aureus* and *E.coli* ($P<0.05$). The non-cytotoxic concentration of fresh juice extract of *A. sativum* was 6.25 µl/mL with the highest cell viability (90.77%). Finally, this investigation highlights that, the potential applicability of *A. sativum* for growth inhibition of mastitis causing pathogens while reveals the significance of herbal plant extracts for the development of novel veterinary drugs with low cost and less side effects.

Keywords: Extract, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, Antibacterial properties

[1]Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science. University of Peradeniya, Peradeniya
[2]National Institute of Fundamental Studies, Kandy
* missakaw@pdn.ac.lk

A Crop-Weather Model to Predict Rice (*Oryzae sativa* L.) Yield Productivity in Anuradhapura and Kurunegala Districts

Silva E.N.I., Samita S. and Ariyaratne M.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rice is the staple food mainly cultivated as a lowland crop in Sri Lanka. A crop-weather model is a simplified representation of complex relationships between weather, climate and crop performance by means of proved mathematical or statistical techniques. This type of models can be used as tools to quantify the effect of weather on crop growth and development. This will help identifying farm-level adaptation to climate change, and find optimum productivity of genotypes in different crop growing environments. This study was focused on two major rice growing districts; Anuradhapura and Kurunegala. Twenty-year weather and rice yield data were used for the study. Weather data were obtained from Natural Resources Management Centre of the Department of Agriculture and the Department of Meteorology while the yield data were obtained from Socio Economic Planning Centre of the Department of Agriculture. Twelve variables were used for study and minimum and maximum temperatures were used after transforming to 10 temperature intervals. Analysis was performed by fitting multiple linear regression models with stepwise variable selection procedure using SAS software package. Seventeen models were fitted to study the effects of different weather variables on cultivated season and different stages of rice production. Rainfall was found to be negatively affecting in *Yala* season and 50% increase in seasonal rainfall has caused 0.5% damage to rice production. Number of days' maximum temperature below 29 °C was negatively impacting on both seasons yieldin Anuradhapura and number of days' maximum temperature higher than 33 °C was positively affecting on yield in both seasons in Kurunegala. Quadratic effect of sunshine duration was positively affecting in *Yala* season. This type of models can be used to study the effect of climatic changes on rice production and the findings from such models can be used to mitigate the impact of potential climate change.

Keywords: Crop-weather model, Climate change, Linear and quadratic response, Rice Yield prediction, Temperature

* mariyaratne@yahoo.com

A Molecular Tool for Identification of Haemoparasites of Sheep in Sri Lanka

Dilinika A.G.S., Deshapriya R.M.C.*, Anupama N.M.T.[1] and Rajapakse R.P.V.J.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Sheep farming is not popular in Sri Lanka and is limited to dry zone and intermediate zones of the country. Haemoparasitic diseases are a major health and economic problem which affects sheep farming in Sri Lanka. Haemoparasitic diseases cause acute health and production issues, sometimes leading to death, poor reproductive performance, premature slaughter, rejection of some body parts at the meat inspection etc. The three main haemoparasites found in sheep are *Babesia* spp. *Anaplasma*spp. and *Theileria* spp. The objectives of the current study were to perform molecular identification of those three main species of haemoparasites in sheep blood collected from Horakelle National Livestock Development Board (NLDB) farm, and to calculate the prevalence of haemoparasitic diseases in the farm where 1500 sheep were reared. Blood samples were taken to a sterile tube from jugular vein of sheep that had not shown any clinical signs. The samples were transported under cool condition to the laboratory. The total DNA was extracted from the blood using a commercial DNA extraction kit (Promega, USA) and the purity was confirmed. Polymerase Chain Reaction (PCR) was carried out using specific primers for each parasitic species. Amplified DNA samples were visualized by using 1% Agarose gel electrophoresis. Out of random 30 samples tested, only one sample was positive for *Theilerialesterquardi*.Thus, the prevalence of *T. lesterquardi* was 3.33%. All blood samples were negative for *Babesiaovis* and *Anaplasmaovis*indicating zero prevalence of those diseases in the farm. The data suggested minimal level of haemoparasitic diseases among the sheep population in Horakelle Farm. Further studies for screening of sheep in other sheep farms and the sequence of *T. lestoquardi* found in Horakelle Farm are recommended.

Keywords: *Anaplasmaovis*, *Babesiaovis*, *Theilerialesterquardi*, Haemoparasites, PCR

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[1]Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science. University of Peradeniya, Peradeniya

* desha1018@yahoo.com

A Novel Chemical Free Device to Decompose Ethylene and Inactivate Airborne Bacteria in Postharvest Supply Chain of Fruits and Vegetables

Sushane C.A.N., Gunawardana M.[1] and Rajapakse R.P.N.P.*
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Global demand for safe, quality and healthy food is increasing day-by-day. The lack of involvement of technology in postharvest handling of fresh fruits and vegetables is responsible for 40% postharvest losses and sometimes it reaches up to 75% in developing countries under hot climates. Amongst all the factors contributing to the postharvest losses of agricultural fresh produce, ethylene production and microbial contamination are the key factors of concern. This study presents a promising nanotechnological application of titanium dioxide (TiO_2) photocatalyst to scrub ethylene from fruit and vegetable storage facilities of the food supply chain. To decompose ethylene and inactivate airborne bacteria in storage atmosphere, a photocatalytic reactor was designed and a prototype was manufactured. The reactor was developed with a TiO_2 coated compact fluorescent lamp (CFL) and an air circulation system. It was operated in a confined storage environment of selected fruits and vegetables and ethylene scrubbing effect was studied. The rate of ethylene generation by different fruits and vegetables and accumulation of ethylene in varying volumes of storages were studied with a F-950 gas analyser. Airborne bacterial inactivation with the photocatalytic oxidation was studied in fruit and vegetable storage facility. As an average a significant ($p<0.05$) reduction (60%) of ethylene was observed in 2 h, when 6 kg of tomato (*Solanum lycopersicum*), lime (*Citrus aurantifolia*) and carrot (*Daucus carota*) were stored separately in a 3,600 L storage volume. A significant ($p<0.05$) reduction (80%) of airborne bacteria was observed in 5 h in the presence of the reactor. This study confirms the high possibility of using TiO_2 photocatalytic technique as a chemical free and safe method of reducing airborne bacteria and ethylene in storage facilities of fresh fruit and vegetable, in a cost effective manner.

Keywords: Ethylene, Titanium dioxide (TiO_2), Photocatalysis, Postharvest losses

[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama
* n_rajapakse@yahoo.com

A Novel Technique of Phospholipase Application in Milk: Would Improve the Cheese Yield of Gouda

Prabashwari T.I.G., Vidanarachchi J.K.*, Prasanna P.H.P., Jayawaradene L.P.I.N.P.[1] and Gunathilake W.L.C.M.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cheese yield is a crucial determinant factor that influences on the profitability of Gouda cheese industry. The objective of the current study was to evaluate the effect of fungal phospholipase A_1 (PLA_1) from *Fusarium venenatum* on the yield of Gouda. In the current study, 4 Gouda samples were manufactured from cow milk: Gouda made with PLA_1 (1.26 g/15 L), Gouda made with PLA_1 (1.44 g/15 L), Gouda made with PLA_1 (1.62 g/15 L) and control Gouda. The most appropriate concentration of PLA_1 treatment on the yield improvement of Gouda was determined out of 3 different concentrations of PLA_1. In the present study, PLA_1 incorporated 3 Gouda were manufactured by adding PLA_1 prior to renneting of the cheese milk. The compositions of all whey samples obtained during manufacturing of Gouda were analyzed. The compositional analysis and sensory evaluation of all Gouda samples were also carried out. The actual cheese yield, moisture adjusted cheese yield, milk protein plus fat adjusted cheese yield, moisture adjusted milk protein plus fat adjusted cheese yield and fat retention co-efficiencies were calculated for all cheese treatments. The use of high concentration of PLA_1 (1.62 g/15 L) in Gouda cheese milk had increased ($P<0.05$) the actual yield, the milk protein plus fat adjusted yield and the moisture adjusted milk protein plus fat adjusted yield by enhancing fat and crude protein composition in cheese. The percentage of fat recovered to cheese was increased ($P<0.05$) with increasing the incorporation level of PLA_1 (1.62 g/15 L) in Gouda cheese milk. The sensory evaluation revealed that the Gouda containing 1.26 g/15 L of PLA_1 was highly preferred ($P<0.05$) by the panelists. This study revealed that 1.62 g/15 L of PLA_1 concentration could be successfully utilized to improve cheese yield of Gouda which can be further improved in industrial cheese trials.

Keywords: *Fusarium venenatum*, Cheese yield, PLA_1, Fat retention, Cheese milk

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[1]Aletek International Pvt. Ltd, Ranaviru Prabhath Cooray Mawatha, Rajagiriya

* janakvid@pdn.ac.lk

Agrobacterium Mediated Transformation of Leaf Discs Explants of *Jasminum polyanthum*

Dissanayake D.M.N.N., Jayawardana N.U.* and Bandaranayaka P.C.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Jasminum polyanthum is an ornamental plant that belongs to family Oleaceae. Despite the existing demand and expected growth of the industry, less attention has been given to the genetic improvement of *J. polyanthum*. The small flower size and non-fruit setting in most *Jasminum* species makes genetic improvement through transgenic and gene editing approaches faster and efficient than traditional breeding. Having an efficient gene transformation and plant regeneration protocols are essential for such approaches. Therefore, present study was conducted to initiate an *Agrobacterium* mediated transformation protocol and tissue culture protocol for *J. polyanthum* either *via* direct or indirect organogenesis. Leaf explants were cultured on Murashige and Skoog's (MS) medium supplemented with several plant growth regulators. After 8 weeks, cultures on Benzyl Amino Purine (BAP) 2 mg/L and Indole-3-Butyric Acid (IBA) 5 mg/L resulted maximum calli initiation percentage of 71%. Naphthalene Acetic Acid (NAA) 0.25 mg/L and Thidiazurone (TDZ) 2 mg/L resulted superior calli in a short period. For *Agrobacterium* transformation, 2 culture media, MS only and MS with NAA 0.25 mg/L and 2 mg/L TDZ, 3 incubation temperatures 7 ^{o}C, 15 ^{o}C, 29 ^{o}C and 2 inoculation methods; streak and liquid culture methods were compared in a factorial experiment. Leaf discs were inoculated with *Agrobacterium rhizogenes* strain MSU 440 harbouring pBIN-YFP vector, with the Yellow Fluorescent Protein (YFP) as reporter gene. One week after co-cultivation, inoculated leaf discs were transferred to the same media with Cefatoxime antibiotic 300 mg/L and maintained under complete darkness at 29 ^{o}C. After 4 weeks, highest transformation efficiency of 42% was observed in the leaf discs inoculated with liquid method and co-cultivated in MS medium with 0.25 mg/L NAA and 2 mg/L TDZ and incubated at 7 ^{o}C. This high efficient *Agrobacterium* transformation and calli initiation protocols will accelerate the crop improvement efforts of *J. polyanthum*.

Keywords: Calli, Thidiazurone, *Agrobacterium rhizogenes*, YFP

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[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* nuj@pdn.ac.lk

Biochemical Characterization of *Cinnamomum zeylanicum* Breeding Materials in Sri Lanka

Thilakarathne E.N.S., Wimalasiri K.M.S.* and Bandaranayaka P.C.G.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cinnamomum zeylanicum, commonly known as true cinnamon or Ceylon cinnamon, has gained worldwide attention due to its health benefits. Sri Lanka holds the largest formally maintained *C. zeylanicum* germplasm in the world. A recent study on morphological and biochemical characterization of the complete germplasm identified 30 accessions based on several criteria. The current study focused on biochemical characterization of 30 accessions to select superior materials for future breeding programmes. An experiment was conducted to find the relationship among essential oil extract and chemical constituents extracted into different solvents; methanol, ethanol, hot water and cold water. Interestingly, methanol extracts had the highest concentration of all the major compounds tested, only about 50 % extraction of cinnamaldehyde was observed in the hot water extract. Bark and leaf samples of 30 accessions were harvested and processed according to traditional method and subjected to biochemical analysis. High Performance Liquid Chromatography (HPLC) analysis was performed with methanol extracts of cinnamon bark and leaves to quantify cinnamaldehyde, coumarin, euginol, cinnamyl acetate, cinnamyl alcohol, cinnamic acid and coumaric acid contents. Accession CRS 102 had the highest cinnamaldehyde concentration of 25.26 mg/g in the bark, while CRS 778 had the highest euginol content of 47.40 mg/g in leaves. Coumarin was not detected in any of the bark samples except for CRS 358 (0.01±0.02 mg/g). Antioxidant activity of bark methanol extracts determined by 2,2-diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging assay showed the highest activity in CRS 200 (97.64±0.18 %). The Total Phenolic Content (TPC) of methanol extracts of bark samples determined by Folin-Ciocalteu (F-C) colorimetric method had the highest TPC in CRS 559 (3.29±0.01 mg GAE/g of sample). Biochemical data together with molecular and morphological analysis will be useful for recommendation of breeding material for immediate breeding or propagation for specific industrial purposes.

Keywords: *Cinnamomum*, Breeding materials, Biochemical analysis, Bark oils

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[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* swarnaw@agri.pdn.ac.lk

Computational Fluid Dynamics Simulation of Heat Pump Based Deep-Bed Drying of Paddy

Kavindi M.A.R., Amaratunga K.S.P.* and Ekanayake E.M.A.C.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Deep-bed drying causes an uneven drying in the vertical profile in industrial scale dryers. Computational Fluid Dynamics (CFD) simulation is a solution for understanding and controlling the drying process to address the problem. The main goal of this study was to develop a CFD simulation model for heat and mass transfer of heat pump based deep-bed paddy drying. To achieve this, a coupled partial differential equations were used to simulate the heat and mass transfer for deep-bed drying of paddy using the COMSOL Multiphysics® simulation program v5.4. The Nonisothermal Turbulent Flow, Heat transfer in fluid and Transport of diluted species interface were coupled with time dependent solver to compute the temperature and relative humidity field in drying air. The equations solved by the Turbulent Flow, k-ε interface is the Navier-Stokes equation, Heat transfer in fluid is the heat transfer equation and Transport of diluted species is the diffusion by Fick's law. All the mathematical models were solved by COMSOL Multiphysics software with the boundary conditions of inlet velocity, inlet temperature and moisture content of drying air and walls consider as no slip condition. CFD simulations were carried out to analyze the external flow of grains and temperature fields at steady state for a controlled volume of a time dependent paddy bed. The simulation was used to predict the temperature and the humidity of drying air at three different locations of the dryer during the drying process. The simulation data of moisture and temperature profiles inside the deep-bed of paddy was verified using experimental data. According to the results, the relative error of the predicted temperature was between -3.6% and 0.51% and the mean relative deviation was between 0.4% and 2.8%. The relative error of the predicted relative humidity was between -18% and 18% and mean relative deviation was 10%.

Keywords: CFD Simulation, COMSOL Multiphysics, Heat pump drying, Navier-stokes equation, Nonisothermal turbulent flow

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[1]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya

* sanath.amaratunga@gmail.com

Designing and Development of Machine for Harvest the crop of Mukunuwanna *(Alternanthera Sessillis*) in Small, Medium and Large-Scale Flat Land Cultivation Fields in Sri Lanka

Manorathna S.N. and Jayatissa D.N.*
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Vegetables are different in Botanical characters. Mugunuwanna (*Alternanthera sessillis*)is commercially cultivated as leafy vegetables in Sri Lanka. Crop is usually manually harvested using sharp Knives or sickles by farmers. Normally farmers don't use machine for harvesting. Cost of harvesting is higher and there is a shortage in skill labor. Farmers must harvest and bundle the crop before supplying to the market. Harvesting machines for Mugunuwanna (*Alternanthera sessillis*)are not available in Sri Lanka. Machines Leafy available in other countries for harvesting leafy vegetables consist with cutting mechanism and storage box with conveyer. Small designs consist only with the cutting mechanism. There is a requirement of a new machine for harvest the Mugunuwanna (*Alternanthera sessillis*)andcrop. The new machine with cutting and conveyor mechanism is of a higher advantage to the small- and large-scale famers. This study will be aimed at designing a new machine to harvest the Mugunuwanna (*Alternanthera sessillis*)and crop with cutting and conveyor mechanism. The new designed machine has reel, cutter bar, and conveyor with the two-stroke engine. New machine is ready for the flat land cultivation field evaluation in Sri Lanka.

Keywords: Designing and development, Harvest, Machine, Mukunuwanna

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* nimaljay@pdn.ac.lk

Determination of an Effective Genomic DNA Extraction Protocol for Different Stages of the Life Cycle of *Meloidogyne* spp. towards Species Delineation by Molecular Methods

Kasuni S.W.A.K., De Costa D.M.* and Prabath Nishantha K.M.D.W.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Root-knot nematodes (*Meloidogyne* spp.)are economically important obligate endo-parasitic pathogens of a wide range of crops and reported to be prevalent in Sri Lanka. There are several species of *Meloidogyne*, however, identification them at species level is difficult by conventional microscopic methods. Accurate identification would be useful to determine the host range of root knot nematodes (RKN) and to identify mixed infections. The objective of the present study was to develop a protocol to extract DNA from different stages of life cycle of RKN towards rapid, sensitive and reliable molecular identification method. Twelve protocols were attempted to extract genomic DNA from different developmental stages of RKN life cycle, namely eggs, second stage juveniles (J2s) and female nematodes. Out of the tested methods, protocol 12 (a modified protocol developed in the present study) was identified as an effective and reliable method for extraction of intact DNA from egg masses of RKN. Quality of the extracted DNA by protocol 12 for downstream applications was checked through PCR amplification using genus-specific primers (194/195) and visualization by gel electrophoresis but the expected PCR product was not resulted in. Therefore, directly crushed egg masses in double distilled water were used as the template DNA for PCR amplification with genus-specific primers and the amplicons with expected band size of 720 bp were resulted in. Crushed J2s in double distilled water was not successful for PCR amplification. Therefore, genomic DNA obtained through direct crushing of egg masses can be used as a template for PCR-based molecular identification of RKN.

Keywords: Developmental stages, Genus-specific primers, PCR amplification

[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya
* devikadecosta@gmail.com

Determination of Pathogenicity Variation of *Colletotrichum* and *Pestalotia* spp. Associated with Rough Bark Disease of Cinnamon

Ehelepola U.W.W.H.K., De Costa D.M.* and Jayasinghe G.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rough Bark Disease (RBD) of Cinnamon is an economically-significant biotic threat to the cinnamon cultivation of Sri Lanka. Based on the presently-available research information, the disease is associated with several pathogenic fungi, namely *Pestalotia* spp., *Colletotrichum* spp., *Botryodiplodia* spp. and *Phomopsis* spp. The present study was conducted to determine the pathogenicity variations of *Pestalotia* spp. and *Colletotrichum* spp. in terms of colony growth rate, disease severity of RBD, and sensitivity variations of the fungal isolates to presently used fungicides. To this end, 14 *Pestalotia* and 6 *Colletotrichum* isolates which were isolated from RBD-infected plants from different cinnamon-growing areas of Sri Lanka and maintained as stock cultures were used. Healthy cinnamon stems were separately inoculated in triplicate, with each fungal isolate by two methods of inoculation, namely cut and paste of a mycelial plug and injecting of a spore suspension. The area of lesion development on the inoculated stems was quantified to determine the pathogenicity variation, 3 weeks after inoculation. Fungicide sensitivity of each fungal isolate was assayed by poisoned food technique using Hexaconazole (1.5 mL/L) and Tebuconazole (0.5 mL/L). The colony growth rate on PDA medium of each fungal isolate was quantified. Lesion development was significantly varied ($P<0.05$) among fungal isolates. The largest lesion area was reported by P8 and P9 *Pestalotia* isolates and C5 *Colletotrichum* isolate, indicating their higher virulence than the rest. P2, P5, and P14 *Pestalotia* isolates and C1 and C2 *Colletotrichum* isolates did not develop lesions on inoculated stems, indicating their non-pathogenic nature. Isolates P8 and C5 showed the highest colony growth rate among *Pestalotia* and *Colletotrichum* isolates, respectively. The colony growth of all the tested fungal isolates was completely inhibited by the two fungicides. Results revealed pathogenicity and colony growth variations of the isolates of *Pestalotia* and *Colletotrichum* spp. infectious to cinnamon.

Keywords: Area of lesion development, Stem inoculation, Fungicide sensitivity, Hexaconazole, Tebuconazole

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[1]National Cinnamon Research and Training centre, Palolpitiya, Thihagoda, Matara

* devikadecosta@gmail.com

Determination of the Efficacy of Formulations of Indigenous *Trichoderma* Isolates for the Management of Root Knot Nematodes in Tomato

Prabhangi J.G.G.C., De Costa D.M.* and Prabath Nishantha K.M.D.W.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The present study was conducted to determine the efficacy of two indigenous *Trichoderma* isolates (i.e. *Trichoderma* 1 and 2) in managing root knot nematodes infecting tomato under *in vitro* and *in vivo* conditions. The effect of *Trichoderma* on mortality of second stage juveniles (J2) and hatchability of egg masses was studied *in vitro* at 24, 48 and 72 h exposure periods. Two types of preparations, namely a spore suspension (2×10^6 spores/mL) and a biomass suspension were used for each *Trichoderma* isolate. The efficacy of the two *Trichoderma* isolates was evaluated on tomato (variety KWR) using three methods of application namely, soil drenching, root dipping and soil mixing. Soil drenching and root dipping were done with spore and biomass suspensions of the fungal isolates and rice bran-based and waste paper-based formulations were used for soil mixing method. Bio assay revealed that, both suspensions of the two *Trichoderma* isolates have significantly increased the J2 mortality and inhibition of egg hatchability after 72 h. Biomass suspension of *Trichoderma* 2 and *Trichoderma* 1 reported higher J2 mortality (66.7% and 60% respectively), and a higher reduction of egg hatchability (41.8% and 40.3% respectively), after 72 h of exposure. Soil drenching of the two isolates as spore and biomass suspensions, significantly reduced the no. of root knots/g of roots in comparison to untreated positive control. Soil drenching of *Trichoderma* 2 isolate as spore and biomass suspensions and soil mixing as a rice bran-based formulation reduced the root galling index significantly ($P< 0.05$). Spore and biomass suspensions of the two isolates when applied as a soil drench significantly increased the fresh weight of healthy roots. Shoot height of tomato was significantly increased by *Trichoderma* 2 waste paper-based formulation when mixed with soil and biomass suspensions of the two isolates and spore suspension of *Trichoderma* 2 isolate.

Keywords: Spore and biomass suspensions, Rice bran-based formulation, Waste paper-based formulation, Juvenile mortality, Egg mass hatchability

[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya

* devikadecosta@gmail.com

Developing a Key for Identification of Nutmeg (*Myristica fragrans* Houtt.) Seeds of Sri Lankan Origin

Rajapaksha A.D., Liyanage T.[1*] and Wimalasiri K.M.S.
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Nutmeg, *Myristica fragrans* Houtt., belonging to family Myristicacea, is an export agricultural crop used for extracting essential oil, oleoresins and nutmeg butter which is widely cultivated in Asian countries including Indonesia, Grenada and Sri Lanka. The objective of the research was to develop a comprehensive identification technique for dried nutmeg of Sri Lankan origin. Fresh, mature nutmeg samples were collected from 13 growing areas covering Kandy, Kegalle and Matale districts in Sri Lanka. The results clearly revealed that there were significant differences ($p<0.05$) among nutmeg collected from 13 locations. According to results, weight, length, diameters (major, medium and minor), bulk density, true density, nutmeg seeds per 100 g and weight of 50 nuts were 5.20±0.13 g, 2.63±0.29 cm, 1.60±0.18 cm, 2.00±0.19 cm, 1.58±0.19 cm, 566.47±26.78 kgm^{-3}, 1007.65±62.21 kgm^{-3}, 19.00±2.77, 243.44±37.33 g, respectively. Percentages of nutmeg volatile oil, nutmeg butter, total ash and acid insoluble ash were found to be 6.45±1.53, 30.56±6.51, 2.04±0.30, 0.11±0.04 respectively, while the total flavonoid content was 57.91±34.55 (Quercetin mg/g). The highest value for coefficient of static friction was recorded on glass surface while the lowest value was recorded on steel surface. Color composition of nutmeg seed powder was obtained using recorded L,a,b values of 24.20±1.56, 22.40±1.06 and 37.60±2.42 respectively. Cluster analysis revealed that all analyzed samples can be classified into four groups which is extremely useful to identify samples with similar physicochemical characteristics, eventhough specific morphological characteristics could not be identified in nutmeg seed powders.

Keywords: Nutmeg, Volatile oil, Oleoresin, Butter, Locations

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[1] Department of Export Agriculture, Matale
* thushariphtd@yahoo.com

Developing a Selective Tea Plucking Mechanism using Image Processing for a Drone-based Tea Harvesting Machine

Abesinghe A.M.S.K., Amaratunga K.S.P.* and Ekanayake E.M.A.C.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

An autonomous, drone-based tea harvesting system has been considered as an alternative solution to the skilled labour crises associated with tea harvesting. To facilitate selective tea plucking by a robotic arm system of this drone, it has identified that the autonomous drone-based tea harvesting system needs an effective detection framework for harvestable tea shoots. Proposed object detection framework should ensure accurate results in segmentation and feature extraction efficiently. Further, it was needed to identify the essentials for using the developed technology for drone-based commercial tea harvesting. Haar-cascade classifier object detection framework and image processing techniques were used to detect harvestable tea shoots in videos automatically. This detection framework was designed using OpenCV Python, and it was trained using total number of 847 images. Out of that, 547 were positive images and 300 were negative images. Testing was done under natural field conditions using 165 real tea leaf samples. RGB (Red-Green-Blue) to grayscale image processing technique was applied to improve the detection results of this classifier. A Raspberry pi camera module was identified as the suitable camera module to use in robotic arm system in this drone for the detection purpose of harvestable tea leaves as the system altogether with the Raspberry pi single board computer is light in weight. The accuracy rate was 57.58% and it emphasized that the classifier has an ability to identify harvestable tea shoots with 2 leaves and 1 bud from the other types of non-harvestable tea shoots. Images were, captured in different angles and different distances from the camera for the testing.

Keywords: Haar-cascade classifier, Image processing techniques, Leaf detection, Object detection

[1]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya

* sanath.amaratunga@gmail.com

Development of a Vigour Test Protocol for Selected Solanaceae Crop Seeds

Abeyrathne M.A.S., Priyantha M.G.D.L.[1] **and Fonseka R.M.***
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Standard Germination (SG) test is used in Sri Lanka to predict seed quality and field emergence. However, the results obtained from the standard germination test sometimes deviate from the field emergence value of seeds belonging to the family Solanaceae. Therefore, this research was carried out aiming to develop a more accurate vigour test protocol than the standard germination test. Three crop species, i.e. tomato (*Solanum lycopersicum* L.), chilli (*Capsicum annuum* L.) and eggplant (*Solanum melongena* L.) were selected for the study. Five laboratory test methods, i.e. SG test, Brick Gravel Test (BG), Cold Test (CT), Standard Accelerated Ageing Test (SAAT) and Saturated Salt Accelerated Ageing Test (SatSAA) were evaluated simultaneously with the Field Nursery Emergence Test (FE) for each species separately. The 5 laboratory tests were arranged in a Completely Randomized Design with five replicates of 50 seeds each. The germination/ emergence percentage and Vigour Index (VI) were calculated for the 5 laboratory tests and the field nursery emergence test. Results indicated that all SG, BG, CT, SAAT and SatSAA were acceptable to predict field emergence value in tomato. CT was the most suited test that could be used to predict the field performance in tomato. There was no suitable laboratory test matched with the FE to predict both field emergence value and field performance of chilli among the tests performed. Both SAAT and SatSAA were suitable to predict the field emergence value in eggplant and the CT was the most preferable test to be used to predict field performance.

Keywords: *Capsicum annuum* L, germination, *Solanum lycopersicum* L, *Solanum melongena* L, vigour test

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[1]Seed Certification Service,Department of Agriculture, Gannoruwa, Peradeniya

* ramyamf@gmail.com

Development of *Agrobacterium rhizogenes*-Mediated Transformation System for Finger Millet (*Eleusine coracana*)

Nashath M.N.F., Jayawardana N.U.* and Bandaranayaka P.C.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Finger millet, *Eleusine coracana* L. Gearth. is a subsistence food and a forage crop that belongs to the family Poaceae. Besides its superior nutritional qualities and health benefits, finger millet is considered as an ideal crop for climate-resilient agriculture in the future. Despite the recent release of the whole genome sequence data, crop genetic improvement efforts are limited on this crop. An efficient genetic transformation system is the key for high throughput gene identification and functional characterization studies. *Agrobacterium rhizogenes*-mediated transformed chimeric plants with transgenic roots and non-transgenic shoots are a widely used efficient system in characterizing root related traits. Therefore, this study was focused on developing an easy and efficient *A. rhizogenes*-mediated transformation system for finger millet cultivar TVFM 02. Three factors; the age of the seedlings, type of explants and presence of sugar in the co-cultivation medium were evaluated in a factorial experiment setup. *Agrobacterium rhizogenes* strain, MSU 440 harbouring pBIN-YFP vector consists of Yellow Florescence Protein (YFP) reporter for plant selection was used. Early stage (3 days old) and 2 leaf stage (6 days old) seedlings were wounded either at root tip or hypocotyl region and inoculated with 24 h bacterial culture using the "streak method", placed on selected media combinations and maintained at 15 ^{o}C for 14 days. Then the plants were transferred to the same media combinations with or without 3% sugar and maintained at 24 ^{o}C at 16 h light and 8 h dark intervals. After 7 weeks, two leaf stage hypocotyl explants co-cultivated and maintained in Murashige and Skoog's medium supplemented with sugar, resulted 24% YFP expressing calli. This finding will set the foundation to future root related gene characterization studies of finger millet.

Keywords: Finger millet, *Agrobacterium rhizogenes*, Root transformation, Yellow Florescence Protein (YFP)

This work was funded by Agricultural Biotechnology Center, Faculty of Agriculture, University of Peradeniya.

[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* nuj@pdn.ac.lk

Development of an Improved Food Packaging Material using Graphene Oxide Nano Composites to Substitute the Multilayer Coextruded Food Packaging Material

Edirisinghe S.A., Mendis B.E.P.*, Gunawardana M.[1] and De Silva R.T.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Efficient packaging ensure the preservation and extension of shelf life of food products, providing a physical barrier to microbial, physiochemical and physical damage. This study was conducted to develop a low-cost food packaging material, with advanced features, aiming to substitute the highly complicated multilayer coextruded films used in the industry. Low-density polyethylene (LDPE) and graphene oxide (GO) nanocomposites were fabricated through melt intercalation with varying GO concentrations from 0 – 10 (w/w %). The masterbatch was synthesized with the assistance of a manufacturing company by incorporating 2% GO into LDPE during the manufacturing of the pallets. The water barrier properties, mechanical properties and the thermal stability of the packaging films were analysed using standard methods. Incorporation of 1% and 10% of GO significantly ($p<0.05$) increased the moisture barrier properties of LDPE films by 18.60% and 34.16% respectively, whereas a remarkable improvement of 53.44% was observed in the films fabricated using 2% GO incorporated masterbatch. A 13.08% increase in the ultimate tensile strength and a 62.4% increase in the Young's modulus were observed in the LDPE film produced from 2% GO incorporated masterbatch. A significant decrease ($p<0.05$) in the elongation at break % was observed with the incorporation of GO due to the lack of dispersion of GO within the film. The thermal stability of the LDPE films did not show a significant difference ($p>0.05$) with the incorporation of GO. However, the elongation at break and the thermal stability of the films could be improved by manufacturing the films through industrial scale machinery which ensures even dispersion of particles. These improvements in mechanical and barrier properties of the films are due to the intermolecular interaction between the LDPE molecules and GO nano particles and could add value to the food packaging material with improved physical properties for potential packaging applications.

Keywords: Low-density polyethylene, Graphene oxide, Nano composites, Food packaging

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[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama

* ereshamendis@agri.pdn.ac.lk

Development of an *In Vitro* Conservation Protocol for Cryopreservation of *Innala* (*Solenostemon rotundifolius* (Poir.) J.K. Morton)

Madhuwanthi M.L.D.I., Edirisinghe E.S.C.[1*] and Eeswara J.P.
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cryopreservation can be considered as the best solution for long term conservation of *Innala* (*Solenostemon rotundifolius* (Poir.) J.K. Morton). Effect of preculture medium and preculture duration on moisture content and viability of cryopreserved samples were investigated with the objective of developing a vitrification based cryopreservation protocol for 2 *innala* accessions (TJ 01 and TJ 04). *In vitro* grown *innala* shoots with the initial moisture content of 94.7-95 g/100g were precultured on Murashige and Skoog medium, supplemented with 3 different sucrose concentrations (0 M, 0.3 M, and 0.4 M) for 3 durations (1, 2 and 4 week), in order to reduce the moisture to an optimal level. The moisture content after preculturing of samples were measured and the remaining shoots were excised and were dipped in loading solution for 15 minutes, followed by ½ PVS2 (Plant Vitrification Solution 2) for 15 minutes. Thereafter, shoots were directly plunged in liquid nitrogen for 24 hours. Then the shoots were thawed in a water bath at 40 ˚C for 1 minute, followed by soaking in the unloading solution for 15 minutes. The soaked shoots were transferred to the regeneration medium and the appearance of the shoots were recorded for 10 weeks. Viability of the shoots were assessed by- 2, 3, 5-Triphenyl tetrazolium test. Even though 0.4 M medium and 4-week preculture duration resulted the highest moisture reduction in both accessions the highest post cryo-survival could be observed for shoots cultured on 0.3 M media for 1-week duration in the accession TJ 01. During the period of regeneration number of brown colour shoots were increased with time. Highest survival of non-cryopreserved shoots was observed in the control medium while survival was highest in 0.3 M for cryopreserved shoots in both accessions, indicating the importance of reduction of moisture content on post cryo-survival.

Keywords: Accession, Cryopreservation, *Innala*, Moisture content, *Solenostemon rotundifolius*

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[1] Plant Genetic Resources Centre, Gannoruwa, Peradeniya
* srimachandi@gmail.com

DNA Fingerprinting of Green Dwarf Coconut Phenotypes in Southern Sri Lanka in Relation to its Resistance to Weligama Coconut Leaf Wilt Disease

Perera K.R.T.A.D.K.P., Perera S.A.C.N.* and Dissanayaka H.D.M.A.C.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Weligama Coconut Leaf Wilt Disease (WCLWD) is a phytoplasma associated coconut disease which has been reported in 2006 in Weligama area in Matara. Since phytoplasma is an intra-cellular obligatory pathogen and coconut is a perennial crop, breeding for resistant cultivars is the most viable option in disease management. Previous studies revealed Sri Lanka Green Dwarf (SLGD) form to possess a high degree of resistance to WCLWD while other forms were highly susceptible. The current research was conducted with the objective of microsatellite DNA fingerprinting of SLGD and assessing molecular diversity among resistant and susceptible SLGD coconuts in Southern Sri Lanka. Thirty SLGD palms including 25 healthy and 5 palms showing WCLWD symptoms were selected from Matara and their morphology was recorded. The DNA profiles were obtained at 06 coconut specific microsatellite marker loci. Amplified PCR products were electrophoresed on 6% polyacrylamide gels followed by silver staining to visualize DNA fragments. Descriptive statistics of morphological data revealed SLGD to be one population with a narrow variation. Molecular data revealed the marker locus CNZ04 to be polymorphic recording a specific band in two WCLWD susceptible SLGD palms while the other loci were monomorphic recording a total of 7 fragments averaging 1.17 alleles per locus. Data were further analyzed using SAS software by the cluster observation method to derive a dendrogram with genotypic data. The results revealed a sub cluster consisting of two susceptible SLGD individuals separating from the main cluster of SLGD individuals. Genotyping at more microsatellites will be required to decipher the true genetic structure of SLGD population and to find out a marker association with WCLWD resistance.

Keywords: Molecular diversity, Phytoplasma, Population structure, SSR markers

This research was funded by the Coconut Research Institute of Sri Lanka.

[1]Genetics and Plant Breeding Division, Coconut Research Institute, Lunuwila

* chandrikaperera2003@gmail.com

DNA Fingerprinting of Sri Lanka Brown Dwarf Coconut (*Cocos nucifera L.*)

Costa P.N.A., Perera S.A.C.N.*, Dissanayaka H.D.M.A.C.[1] **and Meegahakumbura M.G.M.K.**[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Sri Lanka Brown Dwarf (SLBD) is a rare coconut form, which is used as a parent in hybrid coconuts. In the present study, 23 individuals of an *in-situ* SLBD collection in Western and Sabaragamuwa provinces were characterized morphologically and genetically using 11 morphological parameters and 6 coconut specific Simple Sequence Repeat (SSR) markers to determine the genetic diversity of *in-situ* population. The coconut forms, Sri Lanka Tall (SLT), Sri Lanka Green Dwarf (SLGD), Sri Lanka Yellow Dwarf (SLYD), Sri Lanka Red Dwarf (SLRD), *ex-situ* conserved Sri Lanka Brown Dwarf (SLBD) and King Coconut (KC) were used as control palms in the molecular assay. Extracted genomic DNA was PCR amplified and subjected to 6% Poly-Acrylamide Gel Electrophoresis and silver staining to visualize DNA. Morphology of palms was recorded and descriptive statistics were derived to explain morphological data. Genotypic data were analysed by cluster observation method in SAS software. The study population had slight deviations from the reference SLBD for all morphological features indicating a broader distribution within the studied population. A total of 14 SSR alleles were detected at the 6 SSR loci in the molecular analysis, with an average of 2.333 alleles per locus. Mean heterozygosity of 0.215 with a mean Polymorphic Information Content of 0.205 was also recorded. The sample palms grouped into two main clusters in the dendrogram. One cluster comprised of SLT genotypes and the second cluster comprised of KC and Dwarf form genotypes SLGD, SLYD, SLBD, SLRD. Within the KC & Dwarf sub-cluster, SLBD sub clustered with KC, SLRD, SLGD and SLYD. The molecular analysis and morphology revealed that the SLBD population is still in the process of evolution. Thus, it is recommended to carefully select the individual palms to be used in the breeding programme.

Keywords: Genetic diversity, microsatellite markers, molecular analysis, hybrid coconuts

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[1]Genetics and Plant Breeding Division, Coconut Research Institute, Lunuwila

* chandrikaperera2003@gmail.com

Effect of Increased Day Length on Growth of Paddy in a Low Sunshine Zone in Kandy

Kajakarni G., Dharmasena D.A.N.*, Mowjood M.I.M. and Dassanayake K.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Productivity enhancement in agriculture is important to assure food security and increased profitability. Paddy growth depends on many factors and light is one of the most important environmental factors that determines the basic characteristics of growth and development of a paddy plant. The day length and the average rice yields are higher in temperate countries than Sri Lanka. The effect of increased day length on plant growth was investigated. Artificial light was supplied in different growth stages of paddy plant using a red LED light panel in Peradeniya, Sri Lanka. Potted rice plants (BG 252) at vegetative (14^{th} day to 42^{nd} day) and reproductive (42^{nd} day to 63^{rd} day) phases were exposed to red wave band light for equal extended 2 hours before sunrise and after sunset. Plants without light exposure in all growth stages were used as the control. The results revealed that plant height increased with artificial light exposure during the vegetative and reproductive phases. However, tiller initiation was delayed due to artificial light during the vegetative stage. There was no significant effect in average number of leaves per plant and average number of tillers per plant due to artificial light during the growth stage. Further, there was an increase of average plant growth rate due to artificial light exposure during the vegetative stage. Further investigations are needed to explore the effect on yield and varietal differences.

Keywords: Artificial light, Day-length, Paddy cultivation, Plant growth

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[1]Royal Melbourne University, Australia

* nimal.dharmasena@gmail.com

Effect of Ultrasound Treatment on Moisture Absorption of Paddy

Suventhini B., Dharmasena D.A.N.* and Silva F.H.C.A.
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Extended paddy soaking time is one of the major limiting factors in small and medium scale parboiling process. Traditionally, paddy is soaked in cold water for 48 to 72 h. At the end of soaking paddy should reach a minimum of 30% moisture for steaming. Hot water (60-65 ^{0}C) soaking takes 2-4 h, but, it needs expensive boilers and therefore, it is not popular among small-scale millers. However, long duration soaking produces large volume of effluent due to increased number of water changes during soaking. Further, reduction of soaking time is important for increasing milling capacity of small and medium scale millers by increasing the number of batches per year while reducing effluent treatment cost. Therefore, this study was conducted to investigate the effect of ultrasound (US) waves or sonication on cold water soaking time of paddy. The experiment was conducted to study the pure effect of US by isolating the temperature effect. According to the results, US treatment increased the moisture absorption rate of paddy and the initial moisture content of paddy does not increase the soaking rate. However, 12 h (overnight) of pre-soaking reduced the US treatment time to a minimum to reach 30% moisture content for long grain paddy. Further, there is no effect on grain size (Long or short) on moisture absorption rate under the ultrasound treatment. This study has proved that the pure US effect significantly increases the soaking rate of paddy in cold soaking.

Keywords: Moisture content, Paddy cold soaking, Parboiling, Sonication

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* nimal.dharmasena@gmail.com

Establishment of the Green Fluorescence Protein Fused NF-E2-P45-Related Factor 1 (GFP-Nrf1) Expressing Live Monitoring System

Werellagama A.G.S.M., Tsujita T.[1*] and Kodithuwakku S.P.
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cellular and tissue homeostatic condition needs to be kept at optimal levels in maintaining the normal physiology of animals. NF-E2-p45-related factor 1 (Nrf1) plays a vital role as a transcriptional factor in the regulation of genes encoding proteins, maintaining lipid homeostatic in the liver and protective function against environmental changes including oxidative stress, temperature, etc. To exactly delineate the molecular mechanisms of Nrf1 gene, it is useful to have a cell culture based *in vitro* model which enables real time monitoring of Nrf1 expression and localization in the cells. Thus, the current study was focused on generating a conjugated Nrf1-Green Fluorescence protein (Nrf1-GFP) which can be traced under the fluorescence microscopy and to device an ideal transfection protocol. To generate Nrf1-GFP fusion vector, firstly GFP open reading frame (ORF) was cloned into the C-terminal region of full length mouse Nrf1 ORF. Subsequently, resulted Nrf1-GFP fused DNA was cloned into pcDNA3.1V5HisB vector and the sequence verified pcDNA3.1V5HisB/Nrf1-GFP vector was transfected into Hepa1c1c7 cells under different transfection conditions. Proteasome inhibitor, MG132 was used to stabilize the expression. The Cell viability and fluorescence intensity assays were performed along with the different transfection reagent and MG132 concentrations. The response surface methodology (RSM) approach was used to determine the optimum condition for stable expression of the fusion protein. The analysis revealed that 1 µg:1.4 µL of vector to transfection reagent ratio and 0.25 µM of MG132 treatment as the optimum conditions for transfection. Under this conditions significantly higher cell viability and protein expression ($P<0.05$) could be obtained. In overall, the cell line stably expressed the fusion protein which needed to be verified using mass spectrometry. Thus, the new stable Hepa1c1c7 cell line over expressing Nrf1-GFP can be used for bioassays related to oxidative stress responses.

Keywords: Cell viability, Hepa1c1c7 cell line, Nrf1-GFP, Oxidative stress

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[1] Division of Biochemistry, Department of Applied Biochemistry and Food Science, Faculty of Agriculture, Saga University, Saga, Japan
* tada@cc.saga-u.ac.jp

Growth Enhancement of Rice (*Oryza sativa* L.) using Solar Concentrator

Sandaruwani K.H.C., Basnayake B.F.A.* and Mowjood M.I.M.
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Solar radiation is a very important factor for plant growth. Also, initial stage of the plant is very critical because vigorous seedlings ultimately result in strong plants and high yield. The possibility of increasing the growth of rice by concentrating solar energy at the nursery stage was evaluated by this research. For the purpose of concentrating solar energy, Spherical Solar Concentrator refracted through Glass Water Media (SSC) and Mirror Solar Reflector (MSR) were used. Plant growth and environmental parameters under different height of SSC (60 cm and 45 cm), and under MSR, were measured and compared to open environment exposed to direct sunlight and shade. SSC (60 cm), SSC (45 cm) and MSR recorded 1.2, 1.5, and 1.4 times higher solar radiation compared to open environment, respectively. A refracted beam of solar radiation under the SSC changed frequently whereas reflected solar radiation under the MSR remained the same almost throughout the day. Higher germination percentage and average number of leaves per plant were observed in SSC (60 cm) and SSC (45 cm) compared to the open environment. Germination percentage in SSC (60 cm), SSC (45 cm), and MSR were 65.2%, 86.9% and 76.5%, respectively. SPAD readings of 16.5 ± 3.24 and 37.7 ± 4.66 were observed at the fifth week in SSC (60 cm) and at fourth week in the SSC (45 cm). Carrying effect was observed at later stage of the crop. Germination and growth of plants were adversely affected in the experiment with MSR by higher reflected solar radiation. Silver Mirror Solar Reflector was proposed for commercial rice nursery fields.

Keywords: Germination, Rice, Seedling, Solar concentrator, Solar reflector

* benb@pdn.ac.lk

Hepatoprotective Effects of Curcumin against Chemically-Induced Liver Lesions in Rats

Chandrasekara E.D.C.T., Wijesundera K.[1], Gunawardana M.[2], Bogahawatta S.[3] and Kodithuwakku S.P.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Curcumin is one of the most active compounds extracted from *Curcuma longa* (Turmeric) with known medicinal properties. It has been used for centuries in traditional medicine to treat liver diseases and other disorders. Hence, this study was designed to evaluate the hepatoprotecive effects of locally extracted curcumin nano-conjugate against chemically-induced liver lesions in rats. Twenty-four rats were divided into 4 groups (n=6). Three groups received a single intraperitoneal injection of diethylnitrosoamine (DEN) at 30 mg/kg body weight (BW) and thioacetamide (TAA) orally at 50 mg/kg BW once in three days to induce the liver lesion. Daily gavaging of two doses of curcumin was practiced at doses of 100 mg/kg BW and 200 mg/kg BW for two groups of animals under the lesions induction. The negative control group received saline once in three days and olive oil daily for 7 weeks. The positive control group, with induced lesions kept without curcumin treatment. Parameters such as body weights and liver weights, body weight gain (BWG), liver index (LI), gross pathology of livers and liver function enzymes were evaluated. Final body weights and liver weights were not significantly differed from the negative control group ($P<0.05$). Curcumin significantly reduced the BWG and LI ($P<0.05$) in all treated rats. Gross pathological examination revealed that the liver lesions/tumor formation was slowed down by curcumin treatment in a dose dependent manner but no changes were observed in the liver function enzymes AST, ALT and ALP levels. Of the two curcumin doses, curcumin 100 mg/kg BW dose was able to decrease the serum enzymes levels. Overall, the results reflect the potential hepatoprotecive effects of curcumin which may be through antioxidant and anti-inflammatory activities. Therefore, further studies can be recommended to have in-depth understanding of the hepatoprotecive effects of curcumin.

Keywords: Curcumin, Liver index, Liver enzymes, Hepatoprotecive effects

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[1]Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science. University of Peradeniya, Peradeniya
[2]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama
[3]Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
* surangap@pdn.ac.lk

Identification and Study the Biology of an Egg Parasitoid of *Catopsilia pomona* (Lepidoptera: Pieridae)

Malthithara W.A.I. and Hemachandra K.S.*
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The egg parasitoids are important group of biocontrol agents that can be potentially used in agricultural pest control. Local studies on egg parasitoid are scant; hence, this study was conducted with the objectives of examining the biology of a local egg parasitoid species found attacking eggs of *Catopsilia pomona* (Lemon Emigrant). The laboratory studies were conducted using *Cocyra cephalonica* eggs as an alternate host. The fecundity, longevity and the oviposition behavior of the parasitoid were examined. The egg parasitoid species was identified as *Trichogramma* species as per the morphological characteristics. *Trichogramma* sp. female lived for 6.5±0.5 days under the laboratory conditions and average fecundity was 59.2±3.4. Of the egg load, 90% of eggs were laid within first four days after emergence. The highest oviposition was found on the first day and it was 38.1% of total fecundity. The sex ratio of the progeny was 1.16:1 (male: female). The mean parasitoid emergence was 35.1±1.4% when 100 hosts were provided for a parasitoid couple (male and female). Optimum number of adults (males and females) to get the maximum parasitism was five couples per 100 host eggs and three couples per 50 host eggs and the resulting level of parasitism was 91.8% and 81% respectively. Nutritive quality of the diet influences on the longevity, fecundity, age of mating and size of the parasitoid. The longevity of female varied significantly with presence and type of a food supplement (X^2=144.5, df=3.0, P<0.05). Female survived 1.6±0.1days without any food supplements. The survival time was 1.6±0.1 and 3.0±0.2 days for female fed only honey and only eggs of *C. cephalonica* respectively. Females supplied with 50% diluted honey and eggs of *C. cephalonica* supplements lived for 6.4±0.2 days. *Trichogramma* sp. is a potential egg parasitoid that can be promoted as a biological control agent.

Keywords: Biological control, Biological Parameters, Egg Parasitoids, *Trichogramma* species

* kshema@pdn.ac.lk

Identification of an Effective DNA Extraction Method from Paddy Soil Under Different Fertilizer Treatments for Metagenomic Applications to Determine Soil Microbial Diversity

Cooray.P.L.V.N., De Costa D.M.*, Dharmakeerthi R.S.[1] **and Rathnayaka U.K.**[2]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Success of molecular analysis of the soil microbial diversity primarily depends on the efficiency and user-friendliness of the method of DNA extraction from soil. Most of the available soil DNA extraction methods are time consuming, need sophisticated equipment and result in degraded DNA due to numerous handling steps. Present study was done to identify a rapid, efficient, user-friendly and economical direct DNA extraction protocol for paddy soil and determine the suitability of the extracted DNA for further metagenomic applications towards determination of microbial diversity of paddy soils under different fertilizer treatments. Fourteen different protocols were attempted in this study which consisted of six original protocols based on literature and eight other protocols which were modifications of the original protocols. PCR amplification ability was tested for the extracted soil genomic DNA using universal primers for bacteria, fungi, algae and archaea. Among the 14 tested protocols, the one resulted in genomic DNA with high quality, quantity and integrity for downstream applications was selected to extract DNA from the paddy soil samples taken from eight different fertilizer treatments. Among the DNA extraction protocols evaluated, protocol 11 which is a modified method developed in the present study was identified as a rapid, efficient, and economical method for genomic DNA extraction from paddy soil under all treatments. Genomic DNA extracted by protocol 11 was successful to amplify DNA of soil dwelling bacteria, fungi and algae, though amplification of archaea was not successful. Resulted in PCR products were analyzed by single-strand conformation polymorphism (SSCP) and electrophoresis on 3.5 % non-denaturing agarose gel, denaturing formaldehyde agarose gel and polyacrylamide gel. PCR product produced by universal primers for algae was resolved to a certain level of success on a 3.5 % non-denaturing agarose gel, exhibiting multiple number of DNA fragments.

Keywords: Paddy soil, Microbial diversity analysis, Metagenomics

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[1]Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
[2]Rice Research and Development Institute, Bathalagoda, Ibbagamuwa

* devikadecosta@gmail.com

Identification of Inoculum Sources and Determination of Methods of Dissemination of Causal Organisms of Rough Bark Disease of Cinnamon

Kasunika G.W.S., De Costa D.M.* and Jayasinghe G.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rough bark disease (RBD) is of high economic importance in all of the cinnamon growing areas of Sri Lanka due to its ability to cause severe yield losses quantitatively and qualitatively. The present study was conducted to identify the sources of inoculum and methods of dissemination of inoculum of RBD for effective management of the disease. Cinnamon stems with typical RBD symptoms were collected from four different cinnamon fields and isolated the causal organisms. Out of the isolated fungi from the infected plants 80% and 20% were *Pestalotia* spp. and *Botryodiplodia*-like spp., respectively. Pathogenicity of the isolated *Pestalotia* spp. and *Botryodiplodia* spp. was confirmed through Koch's postulates using field-grown cinnamon plants. To determine the inoculum sources, isolations were done from field soils, crop residues and pruned cuts. *Pestalotia*-, *Botryodiplodia*- and *Colletotrichum*-like fungi were isolated by dilution plate technique from crop residues and pruned cuts but not from soil samples. Wind-, seed- and flower-borne nature of the causal organisms were determined through isolations on culture media. PDA plates fixed to capture the wind currents recorded 65% *Pestalotia*-like spp. and 35% *Botryodiplodia*-like spp. Among the fungi isolated from flower parts, 55, 42 and 3% were *Pestalotia*-like spp., *Colletotrichum*-like spp. and *Botryodiplodia*-like spp., respectively. Fungi isolated from seeds consisted of 33% *Pestalotia*-like fungi and 25% *Colletotrichum*-like fungi. Fungal isolates predominantly isolated from inoculum sources were inoculated to field grown plants to prove pathogenicity. Among the inoculated *Pestalotia*-like spp., 88% confirmed pathogenicity. Sixty percent of the fungi isolated from seeds and 95% of the fungi isolated from flower parts, confirmed the pathogenicity through Koch's rules. Findings revealed that *Pestalotia*-like spp. and *Botryodiplodia*-like spp. are responsible for RBD development and crop residues and pruned cuts act as inoculum sources. Flower parts and wind can disseminate the RBD inocula.

Keywords: *Pestalotia* spp., *Botryodiplodia* spp., *Colletotrichum* spp., seed and flower born nature

This work was funded by the National Research Council of Sri Lanka (Grant no. 18-012).

[1]National Cinnamon Research and Training centre, Palolpitiya, Thihagoda, Matara

* devikadecosta@gmail.com

Impacts of Biochar and Compost on Soil Physical and Hydrological Properties of an Alfisol Cultivated with Corn in the Dry Zone of Sri Lanka

Sathiyaseelan P., Munasinghe S.T.[1], Dharmakeerthi R.S. and Vidana Gamage D.N.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Biochar is more recalcitrant than nonpyrolyzed organic materials such as compost, possibly causing more persistent alterations to soil physical properties which in turn influence the soil hydrological dynamics. However, the impacts of single time applied biochar and multiple times applied compost on soil physical and hydrological properties are poorly understood. Therefore, this study quantified the impacts of corn-cob biochar and compost on bulk density, aggregate stability, saturated hydraulic conductivity, gravity drained moisture content, soil texture, thermal conductivity, thermal diffusivity, volumetric heat capacity, and soil water content dynamics of a two and half-year-old experimental field located at Grain Legume and Oil Crops Research and Development Center, *Angunakolapelessa*, Sri Lanka. The treatments included a control, Department of Agriculture recommended synthetic fertilizer rate (DOA), compost (10 Mg/ha repeated every season) + DOA, and corn-cob biochar (17 Mg/ha applied only once) + DOA. Disturbed and intact soil samples were taken to determine soil physical properties while a time domain reflectometry (TDR) and a dual heat pulse probes were used to measure soil water content and thermal properties, respectively. Results of the study showed that after two and half years, neither the single application of corn-cob biochar nor the multiple application of compost induced any significant ($P<0.05$) changes in soil physical properties. In turn, it had a limited impact on soil water content dynamics. Results suggested that the time duration after biochar application may be too short for corn-cob biochar to induce any measurable changes in soil physical properties and consequently the alterations in soil hydrology in an Alfisol. Future studies should collect data over long term to better explain the impacts of biochar and compost on soil physical and hydrological properties under field conditions.

Keywords: Soil physical properties, Biochar, Compost, Hydrological dynamics

[1]Grain Legume and Oil Crop Research and Development Centre, Department of Agriculture, Angunakolapellasa

* dumindavidana@agri.pdn.ac.lk

Investigation on the Biochemical Profiles of Immature Inflorescence and Morphological Parameters of Different Morphotypes of *Kithul* (*Caryota urens*)

Madushan M.N., Perera S.A.C.N.* and Ranasinghe P.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Caryota urens L. known *Kithul*, is an economically and ecologically important, underutilized flowering palm species belonging to family *Arecaceae*. Its immature inflorescences are tapped commercially to obtain various food products. The quality of the *Kithul* sap depends on the chemical composition that depends on the biochemical profiles of the inflorescence. Biochemical profiles can vary with different morphotypes and the study of such relationships will be important to identify suitable morphotypes for sap production. This research was conducted to evaluate the possibility of forming relationships between biochemical profiles and morphological traits of *Kithul*. Data on tapping status, inflorescence maturity and sap production were scored on 15 sample palms. The biochemical assay was conducted by extracting the inflorescence tissues into the solvents; hexane, ethyl acetate and water to trap the chemical compounds of different polarity. Biochemical analysis of solvent fractions was conducted by chemical fingerprinting method spectrophotometry to detect compounds at different wavelengths. Data were analysed by Principal Component Analysis (PCA). The first two principal components accounted for 45.1% of the variance in the 14 original variables. The correlation biplot revealed a highly significant relationship between sap yield and height of the palm. The sap yield, palm height and the number of leaves were revealed to be higher in tappable palms. A highly significant, strongly positive (+0.997) relationship was observed between morning and evening sap production. In addition, the correlation analysis revealed relationships of varying magnitudes among morphological and biochemical fractions. The current study revealed a possibility to form relationships between the biochemical profile and morphological characters. Further investigations will be needed to differentiate the biochemical components observed at different wavelengths in different solvent fractions.

Keywords: Biochemical profile, *Caryota urens*, Morphotypes, Principal Component Analysis

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[1]Industrial Technology Institute, Malabe

* chandrikaperera2003@gmail.com

Isolation and Characterization of Phosphate Solubilizing Bacteria from Vegetable Cultivated Soils

Ekanayake E.M.D.G.K, Dandeniya W.S.* and Nawarathna K.K.K.[1]
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

From phosphorus (P) added to soil some amount get fixed in soil by binding with Ca, Fe and Al limiting P availability for crops. Phosphate solubilizing bacteria (PSB) can be used to solubilize fixed forms of P. This study was conducted with the aim of isolating PSB from rhizospheres of vegetables grown in intensively cultivated soils in *Nuwara Eliya*. Rhizosphere soils were collected from carrot, leeks and beet-root crops grown in 6 fields and analyzed for pH, electrical conductivity (EC), available P, total P, and organic matter content. Phosphate solubilizing bacteria from soils were enumerated on Pikovskya's agar medium which contained tri-calcium phosphate as the only P source. Distinctly different colony forming units (CFU) were isolated for characterization. These isolates were grown in modified Pikovskya's agar medium in which P source was replaced with $AlPO_4$ and $FePO_4$ separately. Phosphate solubilizing rate of 4 isolates were tested in Pikovskya's liquid media. Studied soils were acidic in reaction and EC values ranged between 83.3 to 142.6 µS/cm. Organic matter content varied from 2.05% to 4.61%. Average available P and total P concentrations were 388 mg/kg and 798 mg/kg, respectively. Average abundance of P solubilizing bacteria was 91,241 CFU/gdry soil and 26 bacteria isolates were obtained for characterization. The results indicated isolates can be grown in a general purpose media like tryptic soy broth. Among 26 isolates, clear growth in Al-P media and Fe-P media were observed for 20 and 22 isolates, respectively. Four isolates that did not show hallow zone in Pikovskya's medium solubilized Ca-P at 0.740 mg/kg/h average rate in liquid growth media. Results of this study revealed that soils from Nuwara Eliya region have bacteria that can solubilize Ca-P, Fe-P and Al-P. Potential use of these bacteria isolates for biofertilizer formulation should be further investigated.

Keywords: Phosphate solubilizing bacteria, Tri-calcium phosphate, Iron Phosphate, Aluminum phosphate , Soil

[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya
* warshisd@pdn.ac.lk

Mobility of Phosphorus in a Tropical Paddy Soil as Affected by Phosphate Solubilizing Bacteria

Dias P.A.M., Hettiarachchi A.[1], **Dandeniya W.S.*** **and Dharmakeerthi R.S.**[1]
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

There is a growing interest of using phosphate solubilizing bacteria (PSB) to enhance P availability in rice cultivated soils in Sri Lanka. This study was conducted with the objectives of assessing the effectiveness of PSB on availability of P and P fractionation under continuously saturated (CS) and alternate drying and wetting (ADW) conditions in paddy soil. Soil was collected from a paddy field in Rice Research and Development Institute (RRDI), Bathalagoda. Soil was incubated with PSB in the presence and absence of glucose (Gl) under the two moisture management strategies (CS and ADW). Accordingly, 8 treatment combinations were used; T1 (PSB+CS+Gl), T2 (PSB+ADW+Gl), T3 (CS+Gl), T4 (ADW+Gl), T5 (PSB+CS), T6 (PSB+ADW), T7 (CS), and T8 (ADW). Eppawala rock phosphate (ERP) was added (0.004 g/100 g of soil) equally to all treatments at the beginning. After 30 days of incubation, available P content was analysed. Phosphorus fractionation was done using Hedley sequential fractionation procedure for soils subjected to T1, T2, T3 and T4 treatments. Application of PSB, adding glucose and CS significantly increased ($P < 0.05$) P availability in soil. Highest available P content was observed under T1 (13.43 mg/kg). Among PSB added treatments, highest abundance of PSB at the end of incubation period was recorded in T1 (24,787 CFU/g dry soil). Sum of labile and moderately labile P as a percentage of total P were in the order of T1>T2>T4>T3 (60, 59, 55 and 53 %, respectively). Sum of non-labile and residual P as a percentage of total P were in the order of T3>T4>T1=T2 (47, 46, 40 and 40 %, respectively). Since labile P and part of the moderately labile P contribute for plant available P in the short-run, it can be concluded that application of PSB and CS increase plant available P fractions in soil.

Keywords: Phosphorous, Phosphate solubilizing bacteria, Fractionation, Moisture management

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[1]Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

* warshisd@pdn.ac.lk

Molecular Characterization and Genetic Diversity of *Channa orientalis*

Ekanayake E.M.N.H., Ukuwela K.D.B.[1], Perera W. P. N.[2], Walpita C.N.[3] and Kodithuwakku S.P.[*]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The snakehead fishes in the world have a major economic importance as food and ornamental fish. Sri Lanka is home for six valid species of snakeheads of which two are endemic to the island. *Channa orientalis* is an endemic snakehead species that is heavily utilized in tropical fish export trade. Distinguishing this species from its closely resembling species is a challenge for non-specialists and thus, a low-cost DNA-based identification method would be beneficial. Further, the genetic diversity of this species widespread in the wet zone of Sri Lanka remains unknown. Therefore, the main goals of this study were to determine the genetic diversity of *C. orientalis* and develop a gel-based low-cost molecular marker that permits accurate and reliable identification of *C. orientalis*. Determination of the genetic diversity was mainly carried out through sequencing, phylogenetic and haplotype network analysis of the mitochondrial *CO1* DNA barcoding gene. The development of the gel-based DNA marker for identification of *C. orientalis* was performed through Restriction Fragment Length Polymorphism (PCR-RFLP) analysis. For this purpose, fin clip samples were taken from the fish, which were collected from the four main river basins of Sri Lanka (Mahaweli, Kelani, Nilwala and Kalu). Phylogenetic relationships were estimated through maximum likelihood, and haplotype network was estimated through median-joining methods. Phylogenetic analysis and haplotype network confirmed the presence of two genetically (>8% genetic divergence) and morphologically distinct cryptic lineages of *C. orientalis* among the studied river basins in Sri Lanka. The gel-based PCR-RFLP marker was successful in distinguishing *C. orientalis* from other species of Sri Lankan *Channa* and 23 additional species from elsewhere. These findings indicate the importance of DNA based techniques in discovering cryptic species and development of low-cost species diagnostic methods.

Keywords: *Channa orientalis*, *Channa kelaartii*, *COI* gene, DNA barcoding, PCR-RFLP analysis

[1]Department of Biological Sciences, Factulty of Applied Sciences, Rajarata University of Sri Lanka, Mihinthale
[2]Faculty of Graduate Studies, Sabaragamuwa University of Sri Lanka
[3]Department of Livestock Production, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka
* surangap@pdn.ac.lk

Molecular Identification of Fungi Associated with Rough Bark Disease Infected Cinnamon Plants in Comparison to Healthy Plants

Ananda E.H.M., De Costa D.M.* and Jayasingha G.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Information is lacking if rough bark disease (RBD) of cinnamon is a unimicrobial or polymicrobial infection or a disease triggered by the harmless endophytic fungi by changing their virulence status. The present study was conducted to determine and compare the microbial profiles in different parts of the RBD-infected and healthy cinnamon stems and to identify them by molecular methods. Culturable fungi present on outer bark, inner bark, cortex, vascular region and pith tissues were separately isolated from infected and healthy stems collected from 03 fields, using standard microbiological methods, representing the 03 symptom developmental stages (i.e. initial, moderate and severe) of RBD.Twenty five morphologically different fungal cultures were identified by colony and spore morphology as *Pestalotia*-like spp.(12), *Colletotrichum*-like spp.(4), *Botryodiplodia*-like spp.(2), *Fusarium* spp.(2), *Trichoderma* spp. (1), *Aspergillus niger* (1), *Aspergillus* spp. (1) and unidentified fungi (2). *Pestalotia*-like spp., *Colletotrichum*-like spp. and *Botryodiplodia*-like spp. were prevalent in outer bark and in inner tissues of both healthy and infected stems at all disease developmental stages. *Fusarium* spp. were restricted to healthy stems and infected stems at their initial and moderate stages. Genomic DNA of fungi amplified by ITS1 and ITS4 universal primers. DNA sequencing and homology search identified the *Pestalotia*-like spp. isolated from healthy and disease stems as *Neopestalotiopsis clavispora*, *Pestalotiopsis* sp., *Pestalotiopsis microspora* and *Phanerochaete* sp.. *Colletotrichum*-like cultures isolated from disease and healthy stems were homologous with *Colletotrichum gloeosporioides* and *Colletotrichum fructicola*, respectively. *Fusarium oxysporum* was associated with all tissue types in healthy stems and bark tissues of initial and moderate stages of RBD. *Phanerochaete* sp. was present only in the pith of infected stems. Findings revealed the fungal profiles in different stem parts of healthy and RBD-infected plants at the 03 disease developmental stages dwell as epiphytic and endophytic microbes.

Keywords: Endophytic microbes, Epiphytic microbes, *Pestalotia*-like spp., *Colletotrichum*-like spp., *Botryodiplodia*-like spp.

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[1]National Cinnamon Research and Training centre, Palolpitiya, Thihagoda, Matara

* devikadecosta@gmail.com

Morphological characterization of Cinnamon (*Cinnamomum zeylanicum* Blume) germplasam in Sri Lanka

Madhusanka W.D.M.l., Pushapakumara D.K.N.G.*, Bandaranayaka P.C.G.[1] and Jayasinghe G.G.[2]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cinnamon *(Cinnamomum zeylenicum* Blume) is the most important tree spice that is endemic to Sri Lanka. Enhancement of germplasm or genetic improvement of cinnamon through morphological characterization is important to fulfill the requirements of this industry. Based on the past research carried out, thirty accessions of germplasm collection at the National Cinnamon Research and Training Center were selected on the overall performance in bark cinnamaldehyde, leaf eugenol and bark yield. Subsequently, this research was conducted to characterize the selected 30 accessions on morphological and yield related characters to identify superior accession for different purposes. The collection was characterized for 31 different characters including 14 leaf characters, 4 bark characters, 7 tree characters, bark and leaf yield per stem (wet and dry), branching habit and peeling quality. Principal component analysis (PCA) revealed that there were 7 dimensions of PCA explaining 84.8% of total variance. Quantitative characters of tree spread, total leaf fresh weight/stem, total leaf dry weight/stem, tree height, trunk circumference, total bark wet weight, unit bark wet weight, total bark dry weight, unit bark dry weight contributed to dimension 1 of PCA for 31.2 % of variance. Three cluster analysis were performed separately for morphological characters, leaf yield and yield related characters, bark yield and yield related characters. According to the cluster analysis CRS 358 was the best for total leaf weight/stem whereas CRS 29 which showed highest both total and unit bark weights was the best for bark yield. CRS 637 was the best for peeling quality and also it is the overall best accession for leaf yield, bark yield and peeling quality. A positive correlation was observed between bark yield and leaf length: width ratio. This morphological characterization will be useful to improve new varieties through breeding programs.

Keywords: Cinnamon Accession, Peeling quality, Straightness, Bark yield

[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

[2]National Cinnamon Research and Training centre, Palolpitiya, Thihagoda, Matara

* ngpkumara@pdn.ac.lk

Optimization of RNA Extraction Towards Expression Analysis of *OsNRAMP5* and Evaluation of Plant Growth Under Cadmium Stress in Hydroponically Grown Rice

Gunawardhana L.D.U.T., Bandaranayaka P.C.G.[1] and Jayawardana N.U.*
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cadmium (Cd) is a toxic heavy metal that causes serious threats to human health by accumulating through food chains. Rice, the staple for Asian countries is considered a major route of Cd into the human body. This study was carried out to analyse the expression of *OsNRAMP5,* a key gene involved in the root uptake of Cd in 2 newly improved (Bg 352 and At 362) and 2 traditional rice varieties (*Pachchaperumal* and *Sudurusamba*), exposed to different $CdCl_2$ concentrations (0.5 ppm, 1.5 ppm, and 4.5 ppm) in a hydroponic system. The control was maintained without $CdCl_2$. Roots were harvested 28 days after germination, and the total RNA was extracted using a commercial RNA isolation kit and Trizol reagent. The Trizol protocol yielded better quality and quantity of RNA utilized for first-strand cDNA synthesis. The assessment of the relative expression of *OsNRAMP5* was attempted using gene-specific primers with *OsTUA* as the housekeeping gene. In parallel, morphological parameters were measured where the data showed a significant ($p<0.05$) interaction between the variety and the Cd concentration for plant height (HT) and shoot dry weight (SDW). A significant ($P<0.05$) reduction of HT was apparent in *Pachchaperumal*, *Sudurusamba*, and Bg 352 even at the lowest Cd concentration. Interestingly, *Pachchaperumal*, *Sudurusamba*, and Bg 352 showed a significantly ($p<0.05$) reduced SDW at the lowest Cd concentration while At 362 displayed a significant increase. In the highest Cd concentration, a significant ($p<0.05$) reduction in root length was evident except in At 362. At the lowest Cd concentration, the variety At 362, showed a significantly high root dry weight (RDW). However, at higher concentrations, no significant ($p<0.05$) difference in RDW was evident in any of the varieties. The morphological data obtained suggest that At 362 is more tolerant to Cd compared to *Pachchaperumal*, *Sudurusamba*, and Bg 352.

Keywords: Heavy metal, Rice roots, Traditional rice, Vegetative growth

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[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* nuj@pdn.ac.lk

Possible Amendment of Biochar for Coco-Peat Based Nursery Medium

Dissanayaka D.M.N.S., Weerakkody W.A.P.* and Gunasena A.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Biochar, which is carbonized biomass, has gathered research interest due to its simplicity, cost effectiveness and chemical and physical beneficial characteristics. Even though a large number of studies have been conducted on biochar and soil properties, little is known about the effects of biochar on coco-peat media. Therefore, the aim of current study was to evaluate the performance of biochar in coco-peat media as a nursery growing media. The current experiment was carried out under plant house conditions with three different biochar application rates; 8:2, 6:4 and 4:6 (coco-peat : biochar) as a nursery medium for lettuce (*Lactuca sativa* L.), bell pepper (*Capsicum annuum* L.), brinjal (*Solanum melongena* L.) and tomato (*Lycopersicon esculentum* Mill.) seedlings, keeping 100% coco-peat media as the control medium (10:0). The experiment was performed using a randomized complete block design (RCBD) in three replicates with biochar produced from coconut shell pyrolysis at 1000-1200 ºC. The leaf nutrient contents, vegetative parameters of seedlings, medium parameters and post-transplanting growth parameters of seedlings were monitored as assessment criteria for three weeks of nursery period and two weeks of transplanting period. According to the results, the three biochar application ratios were almost equal in performance (not significantly different, $p>0.05$) to pure coco-peat for all crops, providing the possibility of biochar amendment to coco-peat medium in nurseries. Research concludes that the biochar amendment to coco-peat medium for nursery management of selected green-house vegetable crops was beneficial.

Keywords: Biochar, coco-peat, nursery growing media

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[1]Jiffy Products S.L. (Pvt.) Ltd., Kobeigane, Sri Lanka

* palithaw@pdn.ac.lk

Rapid Monitoring of Soil Nutrients in Paddy Field by Electromagnetic Induction Survey using GEM-2

Chathurangi D.G.P.M., Mowjood M.I.M.* and Galagedara L.W.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Real time nutrient content of agricultural field is important in site specific fertilizer management in precision farming. Direct and continuous monitoring of soils of agricultural fields is difficult, cost and require time. Geophysical methods such as Electromagnetic Induction (EMI) can be used for non-destructive subsurface investigation. GEM-2 is a hand-held, digital, multi-frequency broadband EMI sensor. This sensor measures apparent electrical conductivity (EC_a) of the soil and its variability over large scale rapidly. A paddy field in Mahailuppallama, North Central Province, Sri Lanka was surveyed using the GEM-2 sensor to assess applicability of EM survey and to monitor soil nutrient content of paddy field. Two surveys were conducted on the 13th and 22nd Jan 2020 (before and after fertilization). EC_a variation was mapped in horizontal plane (167 x 45 m^2) at 18 kHz, 30 kHz and 80 kHz frequency levels. Soil samples were collected up to 15 cm after both EM survey to measure soil EC, salinity, pH, total nitrogen, cation exchange capacity (CEC) and texture. EC_a was mapped with Surfer 12 software using block krigging interpolation technique. GEM-2 was able to map the spatio-temporal variability of EC_a in paddy field. The survey maps before and after fertilizer application revealed consistency of the GEM-2 sensor and there is an increase in EC_a after application except in lower range of EC_a. Although the R^2 is low, positive correlations were obtained for all soil parameters except for CEC before the application of fertilizer. This low correlation could be due to the difference in sampling. Therefore, to get a higher correlation and develop a site specific empirical models in order to predict soil properties using EC_a, large scale soil sampling is needed to represent the sample volume of GEM-2. The GEM-2 sensor (EC_a) might have a threshold level of nutrient for response.

Keywords: Apparent electrical conductivity, Electromagnetic induction, GEM-2 sensor, Precision agriculture

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[1]School of Science & the Environment, Memorial University of Newfoundland Corner Brook, NL, Canada

* mmowjood@pdn.ac.lk

Screening of an Effective Bacterial Consortium and Developing Formulations Using Rhizobacteria for Plant Growth Promotion and Management of Selected Soil Borne Pathogens

Karunanayake K.M.S.L. and De Costa D.M.*
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Plant growth promoting rhizobacteria (PGPR) can be used as biofertilizers and biopesticides in place of chemical fertilizers and pesticides, due to their ability to enhance plant growth and manage soil borne plant pathogens. In the present study, 18 bacterial isolates were evaluated for their plant growth promoting and soil borne disease management ability. Among them, 15 were isolated from the rhizospheric soil and three bacterial isolates, namely, *Burkholderia spinosa*, *Bacillus subtilis* and *Bacillus megaterium* were stock cultures of previous studies. Ability of solubilizing phosphorus, production of Indole Acetic Acid, production of fluorescent pigments, ammonification and suppression of selected soil borne pathogens were tested. Bacterial isolates having desirable attributes were checked for their compatibility and grouped into three groups namely, C_1– (*B. spinosa* only), C_2 – (N_2-1 isolate only) and C_3 – (a mixture of G_1-6, G_1-8, N_1-1W, N_1-2, N_2-4W isolates and *B. megaterium*). Three formulations were prepared from the three bacterial groups, using carboxy methyl cellulose (CMC) (F_1), Talc (F_2) and Gum Arabic (F_3) and evaluated *in vivo* using paddy seeds. F_2 and F_3 formulations inhibited seed germination of paddy. F_1 formulation of *B. spinosa*, when used as a seed coating, significantly increased ($P<0.05$) seedling vigor and number of roots on seedlings. Shoot length of the seedling and growth of root hair were significantly increased ($P<0.05$) by C_1 and C_2 when seed coated with F_1. F_1 formulations of C_1, C_2 and C_3 as a seed coat significantly increased ($P<0.05$) shoot and roots dry weights of rice seedlings. *B. spinosa* (C_1) and isolate N_2-1 (C_2) showed the best performances in terms of plant growth promotion of rice and suppression of the tested soil borne pathogens, hence can be considered as potential bacteria for development of biofertilizers and biopesticides.

Keywords: Biocontrol, *B. spinosa*, Seed coating, Seedling vigor, Root and shoot growth

* devikadecosta@gmail.com

Suitability Assessment of Molecular Markers Mapped to *Saltol* Genomic Region for Marker-assisted Selection of Salinity Tolerance in Rice

Thamali K.I.S., Perera S.A.C.N., Suriyagoda L.[1] and Jayatilake D.V.*
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Soil salinity is a destructive abiotic stress that curbs rice (*Oryza sativa* L.) productivity. Hence, development of salt-tolerant varieties is an important aspect in rice breeding programs. *Saltol* is the major genomic region conveying salinity tolerance. In the current study, 19 rice accessions including salinity tolerant references *Pokkali* and *Nona Bokra* were screened for decrease in final germination (FGD), radicle length (RD) and plumule length (PD) using 100 mM NaCl at 9 days after sowing, and was genotyped using 9 simple sequence repeat markers (SSR) mapped to *Saltol* region. Genetic diversity analysis and association analysis were carried out to assess the suitability of the SSR markers for use in marker-assisted selection (MAS) for salinity tolerance. The markers were anchored to a 3.1 Mbp region on the rice chromosome 1, spanning *Saltol* region. A high genetic diversity was reported in *Saltol* region, and *RM3412* was the best marker to capture the diversity, with the highest polymorphism information content (0.61) and 4 alleles. The salinity tolerant references *Pokkali* and *Nona Bokra* have identical allele calls for all the 9 SSR markers. At402 is the genetically closest Sri Lankan variety to *Pokkali* and *Nona Bokra*, and could potentially be used as an elite donor in rice breeding programs. The Friedman test conducted for PD%, RD% and FGD% revealed that varieties Bw400 and At354 were similar to *Pokkali* ($P>0.05$). Out of the 3 tested parameters, PD% was the most sensitive parameter to assess salinity tolerance at early seedling stage and the varieties Bw400, At354, *Nona Bokra*, At402, Bg369 and At353 were similar to *Pokkali* ($P>0.05$). None of the 9 markers tested could be recommended for MAS for salinity tolerance in rice. The findings warrant saturation of the map with new sequence-based markers to better capture the salinity tolerance conveyed by *Saltol* region.

Keywords: *Saltol*, SSR, Marker-assisted selection, Salinity tolerance, Genetic diversity

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[1]Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

* djayatilake@agri.pdn.ac.lk

Testing the Effect of Antibiotic Residues for the Composting Process and Evaluating the Use of Composting Process and Biochar Preparation to Reduce Antibiotic Residue Levels in Poultry Litter

Edirisinghe E.D.N., Karunarathna A.K.[1], Fernando B.R.[2] and Wijayagunawardane M.P.B.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Presence of residual antibiotic traces in poultry manure poses a risk on environment and human health. The inappropriate disposal and land application of such contaminated litter can bring up serious repercussions. Therefore, this experiment was designed to evaluate the fate of antibiotic enrofloxacin through the feeding, littering and post-treatment of litter. The experiment was conducted by feeding chickens with enrofloxacin added feed, and monitoring residual enrofloxacin in the litter and residual traces occur after aerobic composting and thermal treatment through pyrolysis. Also, the effect of antibiotic tetracycline on composting of poultry litter was assessed by composting tetracycline added poultry litter in controlled composting reactors. The antibiotic concentrations of the samples were quantified using liquid chromatography tandem mass spectrometry (LC-MS-MS). The results revealed that feeding of enrofloxacin to poultry at a rate of 10 mg/ kg for 3 consecutive days leads to occur enrofloxacin residue in poultry litter at a rate of 2.65 mg/kg. The regulated composting of poultry litter for 25 days decreases the enrofloxacin content to 1.4 mg/kg, which showed that residual antibiotics remain in poultry liter even after thermophilic composting. In contrast, thermal treatment of poultry litter by pyrolysis at 500 °C for 30 minutes to biochar reduces the enrofloxacin levels to below < 1 µg/kg. Adding of tetracycline to poultry litter at rates from 66 to 660 mg/kg significantly reduces the composting activity as evident by lowered temperature development, lower moisture losses and slower volatile solid losses in treatment samples. The temperature and volatile solid changes are considered indicative parameters of thermophilic composting bacteria activities, thereby, it is concluded that presence of tetracycline severely affect the microbial development in composting. The results indicate that the aerobic composting and thermal treatment reduces the enrofloxacin residue in poultry litter below the biohazardous level.

Keywords: Antibiotic, Composting, Poultry litter, Pyrolysis

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[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya

[2]Department of Veterinary Public Health and Pharmacology, Faculty of Veterinary Medicine & Animal Science, University of Peradeniya, Peradeniya

* missakaw@pdn.ac.lk

Factors Affecting on Production of Soy Bean Curd (*Tofu*)

Sandaruwan E.D.A., Wimalasiri K.M.S. and Rebeira S.P.[1*]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The study was conducted to evaluate suitable factors affecting the manufacturing of soybean curd. The factors evaluated were the genetic makeup of soybean, coagulant, and the milk extraction method. Two varieties (PB 1, PM 13) and two lines (ANKSBMW 1 and ANKSBMB 1) of soybean were used in order to select the best genetic makeup that affects the production of *tofu*. The coagulants used were calcium chloride ($CaCl_2$), calcium sulfate ($CaSO_4$), and citric acid. Milk extraction methods were colloidal mill and domestic blender. Among these varieties and lines PM 13 variety was the best variety for the production of *tofu*. The proximate composition of PM 13 flour was 8.9±0.8% moisture (dry basis), 2.42±0.03% fat, 52.5±0.99% protein, and 1.8±0.2% ash. The composition of *tofu* prepared using PM 13 variety was 14.54±0.24% nitrogen, 70.6±0.35% moisture, 5.98±0.07% total soluble solids, and 6.39±0.01 pH. The geometric parameters of the PM 13 variety were 7.17±0.51 length, 5.7±0.4 width, and 4.91±0.27 thickness. According to this research best coagulant was calcium chloride and the best milk extraction method was the colloidal mill. The *tofu* prepared using calcium chloride as the coagulant showed 6.2±0.2 pH, 70.20±2.4% total soluble solids, and 242.0±17.01 g *tofu* yield. Soy milk extracted from using 200 g of seed and 1200 mL water in a colloidal mill showed 6.55±0.52 pH and 7.03±0.21 total soluble solid with a milk yield of 603.33±10.25 mL.

Keywords: Soybean curd, Coagulant, Colloidal mill, Soybean

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[1] Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya
* srikanthi.rebeira@yahoo.com

A Comparative Study on the Presence of Pesticide Residues in Selected Vegetables Grown in Conventional Agricultural Fields and Good Agricultural Practices (GAP) Certified Fields

Batugedara B.V.C.R., Mendis B.E.P., Lakshani P.W.Y.[1*] and Magamage C.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Adoption of recommended Good Agricultural Practices (GAP) has been identified as an option to ensure safe and sustainable farm produce. "Sri Lanka Good Agriculture Practices/ SL-GAP" was launched in 2016 with the assistance from the Department of Agriculture, Sri Lanka, aiming to supply safe produce to consumers. However, information on the presence of pesticide residues in fresh produce obtained from GAP certified fields is meager. The overall objective of this study was to compare between GAP certified agricultural produce, and conventionally farmed agricultural produce, mainly the vegetables for the presence of pesticide residues. Random sampling was performed to obtain produce from Nuwara-Eliya and Puttalam districts. Sample extraction was performed according to the Association of Analytical Communities (AOAC) Official Method 2007.01 and analysis was done using Liquid Chromatography-tandem Mass Spectrometry (LC-MS/MS). Out of 26 pesticides, 16 pesticides were absent in any of the samples tested. Moreover, there was no association ($p>0.05$) between, the type of farming system vs. presence of any pesticide residue and selected district vs. presence of any pesticide residue. However, presence of residues of carbendazim was significantly different ($p<0.05$) between samples collected from GAP fields and conventionally farmed fields. More specifically, presence of carbendazim residues in conventional farming system was higher than that of GAP certified fields. Any of the observed levels of tested pesticide residues in produce obtained from both farming systems did not exceed the Maximum Residue Levels (MRLs) specified by the Codex Alimentarius Commission (CAC) and the MRLs issued by the Gazette Extraordinary, No. 2023/34, 14.06.2017 issued by the Government of Sri Lanka. It is advisable to disseminate this information especially among GAP farming communities, through the agriculture extension network, so that they could improve to achieve expected outcomes of the SL-GAP programme in ensuring the quality and safety of agricultural produce.

Keywords: Pesticide residues, Conventional farming, Good Agricultural Practices (GAP) certified farming, Liquid Chromatography-tandem Mass Spectrometry (LC-MS/MS), Maximum Residue Levels (MRLs)

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[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya

* jayayoshil@yahoo.com

Analysis of Pesticide Residues in Processed Rice from Selected Locations in Sri Lanka

Kotambewaththa I.H., Hemachandra K.S.* and Lakshani P.W.Y.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Growing concerns over food safety and the expanding world agricultural trade have led to the enforcement of strict pesticide regulations across the world including Sri Lanka. Thus, this study was conducted with the objectives of assessing the pesticide use in rice cultivation in selected locations in Anuradhapura, Polonnaruwa, Kurunegala, Hambanthota and Ampara districts and evaluating the pesticide residues in processed rice grains with respect to 25 widely used pesticides in Sri Lanka. Results of the farmer survey indicated that chemical pesticides were the primary choice of all farmers for pest management. Mostly used weedicide and insecticide in all 5 districts were Pretilachlor 300g/LEC and Carbosulfan 200g/LSC respectively. There was no such trend for the fungicide use. Rice samples were extracted according to the QuEChERS method and concentrated samples were analyzed by LC-MS-MS. Thiamethoxam, Imidacloprid, Carbofuran-3-hydroxy, Chlorantraniliprole, Fipronil, Lufenuron and Tebuconazole were detected in 10, 2.5, 22.5, 5, 2.5, 5 and 2.5% of the samples respectively and residue level of Imidacloprid was found above the Maximum Residue Level. Presence of pesticide residues in the tested rice samples is a great concern; a thorough study should be conducted taking more rice samples along the processing chain.

Keywords: Rice, LC-Ms-MS, QuEChERS

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[1]Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya

* kshema@pdn.ac.lk

Analysis of the Physicochemical and Sensory Properties of the Most Commercially Available Yogurt and Curd Products in the Market and Determination of Formalin in Curd

Madubhashini G.G.S., Mendis B.E.P.* and Silva A.B.G.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

There are no mandatory product standards in Sri Lanka for yogurt and curd, and a wider variation exists among market available products in terms of quality. This research was conducted to evaluate the physicochemical and sensory properties of selected yogurt (YA, YB, YC, YD & YE) and curd (CA, CB & CC) brands that are highly popular among Sri Lankan consumers. Further, formalin in selected curd brands was analysed to determine the possible adulteration. Physico-chemical properties (milk solid non-fat, titratable acidity, moisture content, fat content, protein content, pH and colour) of yogurt and curd brands were analysed according to AOAC methods and Sri Lankan standards. Sensory properties (colour, flavour, texture and overall acceptability) of yogurt and curd brands were evaluated using hedonic test. Data were statistically analysed using SAS 9.0 one-way analysis of variance (ANOVA) and the Duncan's multiple range tests. Significant differences ($p<0.05$) in physico-chemical properties were observed among yogurt brands. Maximumfat content of 4.72% (w/w) was observed in YA yogurt brand and the maximum protein content of 4.27% (w/w) was observed in YC yogurt brand. Physicochemical properties except moisture content and protein of the curd brands showed significant differences ($p<0.05$). Maximum fat content of 7.29% (w/w) was observed in CA curd brand and the maximum protein content of 4.86% (w/w) was observed in CC curd brand. Significant differences ($p<0.05$) in mean scores of sensory properties were observed among yogurt and curd brands analysed separately. All the curd brands exhibited negative results for the presence formalin. In conclusion, all tested yogurt and curd brands were in acceptable quality and YD yogurt brand and CB curd brand had highest consumer acceptability. However, it is recommended to have mandatory product standards for yogurt and curd to maintain the uniformity among the brands and to assure better quality.

Keywords: Yogurt, Curd, Physicochemical properties, Sensory properties, Formalin

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[1]Department of Nutrition, Medical Research Institute, Colombo 08

* ereshamendis@agri.pdn.ac.lk

Anti-cancer Effect of *Flueggea leucopyrus* (Katupila) and *Annona muricata* (Custard Apple Fruit) Plant Extract

Nadeeshani P.D., Rajapakse R.P.V.J.[1], Jayasinghe U.L.B.[2] and Wijayagunawardane M.P.B.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Katupila (Flueggea leucopyrus) and Custard Apple (Annona muricata) plants used in indigenous medicine in Sri Lanka are having important anti-carcinogenic effects. Thus, the present study was formulated to investigate the effect of Katupila, Custard Apple fruits and Custard Apple leaves on cervical cancer progression. The plant materials were subjected to methanol and water extractions and freeze dried. A set of serial dilutions was prepared from each extract at concentrations of 1:1. 1:2, 1:3, 1:4, 1:5, 1:6, 1:7 and 1:8 (v/v; water: extracts). A 10 µl drop of dilutions were added to a normal Vero cell lines, which were already incubated with 90 µl of culture medium until subconfluency, and further incubated for 24 hours. MTT assay was performed to detect the toxicity. A non-toxic doses selected from each plant material were 1:6, 1:7, 1:5, 1:3, 1:7, 1:6 for Katupila methanol, Katupila water, Custard Apple fruit methanol, Custard Apple fruit water, Custard Apple leaves methanol and Custard Apple leaves water extracts, respectively. The selected doses were added to subconfluent HeLa cell cervical carcinoma cell line and incubated for 24 hrs followed by MTT assay. All the plant materials used had significant ($P<0.05$) reduction of cancer cell development. Moreover, Katupila leaves extract had significantly higher ($P<0.05$) efficiency than others plant materials. The study concluded that, Katupila leaves, Custard Apple fruit and Custard Apple leaves were having anti-proliferative effect on cervical carcinogenesis in vitro, where Katupila leaves were comparatively more effective. Thus, the plant materials tested can be efficiently utilized to develop an organic anti-cancer treatment. Studies need to be expanded to discover an anti-cancer drug from indigenous medicinal plants.

Keywords: Katupila, Custard Apple, anti-carcinogenic, cell line, cervical

[1]Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science. University of Peradeniya, Peradeniya
[2]National Institute of Fundamental Studies, Kandy
* missakaw@pdn.ac.lk

Antimicrobial Potential of Brans of Sri Lankan Traditional Rice and New Improved Rice Advanced Breeding Lines against *Staphylococcus aureus*

Kumari A.G.A.C., Rajawardana D.U.[1], Abeysekera W.K.S.M.[2], Wimalasiri K.M.S.[*], Abeysekera W.P.K.M.[3], Weerasinghe W.D.P.[4] and Jayanath N.Y.
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rice (*Oryza sativa* L.) is an important cereal and the staple food of half of the world's population including Sri Lanka. Rice bran is the outer layer of the rice grain and reported to have antimicrobial activities against foodborne pathogenic bacteria. However, the antimicrobial properties of rice bran has not been explored adequately in Sri Lanka. The objective of the research was to evaluate antimicrobial potential of bran of selected Sri Lankan traditional rice and new improved rice breeding lines against a foodborne pathogenic bacterium, *Staphyloccus aureus*. Seventy percent ethanolic bran extracts of two Sri Lankan traditional rice varieties namely *Kalu Heenati* and *Pachchaperumal* and six new improved rice advanced breeding lines namely Bw-312, Bw-12-574, Bw-14-7-5, Bw-14-509, Bw-13-3-1184 and Bw-15-971 were prepared. Concentration series of rice bran extracts (4 mg/ml, 6 mg/ml, 8 mg/ml, and 10 mg/ml) were evaluated against *S. aureus* (ATCC 25923) using agar spot and well diffusion assays *in vitro* (n=3 each). Significant differences ($P<0.05$) among selected rice varieties for antimicrobial potential against *S. aureus.* Bran extracts of traditional rice varieties exhibited significantly higher ($P<0.05$) antibacterial activity against *S. aureus* than the new improved breeding lines. Interestingly, irrespective of traditional or new improved types, bran extracts of red rice showed significantly high ($P<0.05$) antibacterial activity. Among traditional red rice variety, *Kalu Heenati* has shown the highest antibacterial activity against *S. aureus* at 10 mg/mL while the second highest activity was shown by *Pachchaperumal* at the same concentration. In conclusion, *Kalu Heenati* and *Pachchaperumal* possess rice bran of substantial antimicrobial activity against *S. aureus.*

Keywords: Traditional rice, New improved rice, Rice bran, Antimicrobial activity

[1]Food Technology Section, Industrial Technology Institute, Malabe
[2]Department of Agricultural Technology, Faculty of Technology, University of Colombo, Colombo
[3]Herbal Technology Section, Industrial Technology Institute, Colombo,Sri Lanka
[4]Regional Rice Research and Development Centre, Bombuwala
* swarnaw@agri.pdn.ac.lk

Antioxidant Capacity of Aqueous Extracts of Dehydrated *Bacopa monnieri*

Dhanushka T.H.S., Illeperuma D.C.K.*, Gunathilake K.D.P.[1], Jayasinghe C.V.L.[1] and Jayasekara P.W.G.N.R.[2]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Bacopa monnieri contains a wide range of bioactive compounds that remarkably affect brain functions and enhance memory. Even though it is extensively used to prepare decoctions in traditional medicine, bitter flavour limits its consumption as a salad and also use in the food industry. Therefore, dehydrating *Bacopa monnieri* and investigating the effect of aqueous extraction until the original volume reduced to one-eight (8:1) and two-eight (8:2) on antioxidant capacity of the decoctions were the focus of this study. Dehydration at 50 ± 1 ^{o}C for 12 h in a cabinet air dryer reduced the moisture content from 84.97 ± 1.75 to 11.41 ± 0.27%. Decoctions were prepared by heating the dehydrated samples at 60 ± 5 °C in clay pots while maintaining a solid to water ratio of 6:100 (g/mL). Time required for a volume reduction of 8:1 and 8:2 was 135 and 90 min respectively. Significantly higher ($p<0.05$) DPPH radical scavenging activity (92.2 ± 0.5 and 89.1 ± 0.6% inhibition), lipid peroxidation activity (61.6 ± 1.1 and 50.8 ± 0.4% inhibition), total saponins (73.4 ± 1.1 and 48.4 ± 1.2%) and total antioxidant capacity (8.23 ± 0.6 and 4.08 ± 0.9 mg AAE/mL extract) of 8:1 and 8:2 decoctions, respectively, were evident. Even though 2-fold concentration was expected between 8:1 and 8:2 extracts, 3.5, 21.4, 51.6 and 104.1% increase in DPPH radical scavenging activity, lipid peroxidation activity, total saponins and total antioxidant capacity, respectively, was evident. Yields of the two extracts were 0.110 ± 0.017 g/mL (8:1) and 0.078 ± 0.007 g/mL (8:2). Even though extraction in 8:1 resulted in a 15% more yield than that in 8:1, considering the energy efficiency, extraction of dehydrated *Bacopa monnieri* in 8:2 could be recommended for spray drying or any other applications.

Keywords: *Bacopa monnieri*, Bacosides, Antioxidant activity, Decoctions

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[1]Department of Food Science and Technology, Faculty of Livestock, Fisheries and Nutrition, Wayamba University, Makandura, Gonawilla

[2]Museum of World Buddhism, Sri Dalada Maligawa, Dalada Street, Kandy

* dchamaraki@hotmail.com

Chemical Changes Associated with Deep-Frying of Potato Slices

Wijetunga E.G.T.S.T., Madhujith T.* and Weerasinghe W.M.P.B.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Edible oils undergo different chemical changes such as hydrolysis, thermal oxidation, polymerization, and isomerization. The objective of this study was to assess the level of oxidation and quantify the content of *trans* fatty acid (TFA) generated in frying oils and fried products during the reuse of the same oil for frying. Coconut, RBD palm and RBD soybean oils were used as frying oils to fry potato slices. Oils were heated to 170 °C for 12 minutes in pans and potato slices of equal thickness and diameter were fried separately over 3 minutes at 170±5 °C maintaining potato to oil ratio of 1:8.5. On completion of the first frying cycle, a sample of oil and fried potato chips were collected. The same oils were reused for frying a fresh batch of potato slices after a lapse of 24 hours and frying continued up to five cycles in total. Both oil and potato chips were tested for peroxide value (PV), TBARS, *p*-anisidine value (*p*-AV), and TOTOX value. The fatty acid profile and TFA content were determined using gas-liquid chromatography. PV, *p*-AV and TOTOX values of palm and soybean oils and potato chips fried in palm and soybean oils significantly ($p<0.05$) increased with frying cycle while they remained unchanged in coconut oil. TFA content in potato chips fried in soybean and palm oils at the end of the 5th cycle was 1.5 and 1.1%, respectively while that of soybean and palm oil samples was 3.6 and 1.6%. Neither coconut oil nor chips fried in coconut oil showed detectable levels of TFA at the end of the 5th cycle. Coconut oil showed better stability against thermal oxidation than palm and soybean oils in frying potato slices.

Keywords: Deep-frying, Level of oxidation, *Trans* fatty acid, Peroxide value

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[1]Division of Pasture and Fodder Crops, Veterinary Research Institute, Gannoruwa, Peradeniya

* tmadhujith@agri.pdn.ac.lk

Comparative Study of Extraction of Polyphenols in Black Tea and Green Tea under Different Time-Temperature Combinations and their Antioxidant Capacity

Kaushalya G.A.H, Arampath P.C.*, Gunawardana M.[1] and Edirisinghe J.[2]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tea is the highest consuming beverage next to water. Among polyphenols rich plants, tea plays a major role with respect to the quantity and the quality of the polyphenols. Green tea and black tea are the most consuming tea types. Consumption of green tea and black tea has been increased during past decade because of their health promoting abilities. Due to the health claims tea polyphenol extraction is become an industrial application. These polyphenols are important because of the presence of antioxidants. Free radical formation is the leading cause for number of chronic diseases and antioxidants are able to fight against free radicals. Among available conventional and non-conventional extraction methods ultrasound assisted extraction method is considered as a green technique. The antioxidants in tea were significantly affected by temperature of extraction, steeping time and tea type ($P<0.05$). Increasing the temperature and steeping time antioxidant capacity was increased, but comparatively low antioxidant stability was observed in green tea with time. In comparison to black tea green tea infusions provide more antioxidants. The highest antioxidant activity for green tea was observed at 90 ^{o}C after 1 min of brewing (1530.97±68.91 µM), whereas that for black tea was observed at 80 ^{o}C after 4 min of brewing (1449.34±71.2µM). Extraction temperature, extraction medium and type of tea highly affect on antioxidant activity during soxhlet extraction ($P<0.05$), which is a better technique for black tea polyphenol extraction in comparison to green tea polyphenol extraction ($P<0.05$). Ultrasound assisted extraction is the most preferred extraction technique for both black tea and green tea polyphenol extraction ($P<0.05$), suggesting that it is the most suitable extraction technique for green tea catechin extraction.

Keywords: Green tea, Black tea, Antioxidant activity, Polyphenol extraction, Ultrasound assisted extraction

[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama
[2]Sri Lanka Tea Board, Colombo

* pcarampath@gmail.com

Comparative Study on Functional Properties of Insoluble Dietary Fiber Extracted from Bark Waste of Cinnamon (*Cinnamomum zeyalanicum*), Refuse Tea (*Camellia sinensis*) and Empty Fruit Bunch Residue of Oil Palm (*Elaeis guineensis*)

Thilakarathne M.G.O.S., Vidanarachchi J.K.*, Kodithuwakku S.P., Himali S.M.C. and Lansakara L.H.M.P.R.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The objective of the current study was to conduct a comparative study on various functional properties of insoluble dietary fiber (IDF) extracted from bark waste of cinnamon (*Cinnamomum zeyalanicum*), refuse tea (*Camellia sinensis*) and empty fruit bunch residue of oil palm (*Elaeis guineensis*). Soluble dietary fiber (SDF) and IDF contents in cinnamon bark waste (0.84 ± 0.14 and 78.86 ± 0.10 %, respectively) and empty fruit bunch residue of oil palm (1.34 ± 0.14 and 75.36 ± 1.23 %, respectively) were not different ($P>0.05$). The lowest ($P<0.05$) IDF content (43.87 ± 0.16 %) and the highest ($P<0.05$) SDF content were observed in refuse tea (9.14± 1.58 %). IDFs from these materials were isolated by treating with a neutral detergent solution. The highest ($P<0.05$) water holding capacity (WHC) was observed in IDF obtained from refuse tea (IRT), followed by IDF obtained from empty fruit bunch residue of oil palm (IOPR). The lowest ($P<0.05$) WHC was observed in IDF obtained from cinnamon bark waste (ICBW). WHC of IRT, IOPR and ICBW were 7.33 ± 0.14, 5.09 ± 0.05, 4.46 ± 0.05 mL/g, respectively. Oil holding capacity of IRT (408.55 ± 0.87 %) and ICBW (395.23 ± 8.35 %) were not different ($P>0.05$) and those values were higher ($P<0.05$) than that of IOPR (287.59 ± 9.53 %). Total polyphenolic content (TPC) of IRT (133.75 ± 21.83 GAE mg/g) was higher ($P<0.05$) than that of ICBW (92.09 ± 1.92 GAE mg/g) and IOPR (26.19 ± 3.69 GAE mg/g). The highest ($P<0.05$) total antioxidant capacity (TAC) was observed in ICBW (347.50 ± 20.83 mmol Fe^{2+}/g) followed by IRT (258.91 ± 27.34 mmol Fe^{2+}/g) and the lowest was observed in IOPR (212.38 ± 29.92 mmol Fe^{2+} /g). These results indicated that IRT and ICBW have more functional properties than IOPR.

Keywords: Cinnamon, Refuse tea, Oil palm, Insoluble dietary fiber, Functional properties

[1]Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka

* janakvid@pdn.ac.lk

Comparative Study on Quality and Safety Aspects of Marine Fishery Chain of Selected Fishery Harbors in Sri Lanka

Fernando S.R.T., Rajapakse R.P.N.P.* and Wickramasinghe W.S.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study aimed to carry out a comparative investigation on quality and safety aspects of marine fishery chains of selected fishery harbours of Sri Lanka. Beruwala, Dikkovita and Kudawella fishery harbours were selected as the study locations out of 21 existing harbours in Sri Lanka, based on the scale of operation, infrastructure facilities, number of multi-day boats registered and socio-economic factors. Information were collected from randomly selected 50 multi-day boats at each fishery harbour mentioned above using a validated questionnaire. It contained 49 statements under the 3 main aspects of marine fishery chain namely harvesting, on-board handling and unloading. Collected data were statistically analysed based on 5 quality and safety criteria such as; design of the boat, fishing gears & harvesting practices, method of preservation, method of handling & on-board hygiene & safety and method of unloading handling practices & hygiene & safety, using sign test ($p<0.05$) to identify the compliance of quality and safety requirements with internationally recognized guidelines. Both Beruwala and Kudawella fishery harbours comply only with two quality and safety criteria; fishing gears & harvesting practices and method of handling on-board hygiene & safety. However, Dikkovita fishery harbour, which targets only the export market complies with four quality and safety criteria except method of preservation. Thus, Dikkovita fishery harbour maintains significantly ($p<0.05$) high quality and safety standards compared with other two fishery harbours for 5 quality and safety criteria studied. It is clear that the handlers of the marine fishery chains do not pay much attention on the quality and safety aspects of the harvested fish targeting local consumption. Therefore, attention should be paid to improve the quality and safety of locally consumed marine fish, by adhering to the basic quality and safety standards identified internationally.

Keywords: Quality, Safety, Fishery harbors, Criteria, Comparative study

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[1]Department of Fisheries and Aquatic Resources, Colombo 10

* n_rajapakse@yahoo.com

Compositional Variation of Commercial Brands of Coconut Oil and Palm Olein, and Repeated Deep Frying Oil

Kumari L.C.P., Arampath P.C.* and Silva A.B.G.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The study was conducted to determine the quality of commercially available coconut oil and palm olein in Sri Lanka and to compare the composition of coconut oil and palm olein following repeated deep-frying with food. Moisture content, iodine value, and free fatty acid content were measured in both selected coconut oil brands (C1, C2, C3 and C4) and palm olein brands (P1, P2, P3 and P4) using standard methods. There was no significant difference ($P>0.05$) in moisture content among 4 coconut oil brands and 4 palm olein brands. But there was a significant difference ($P<0.05$) in Free fatty acid contents among the 4 coconut oil brands and four selected palm olein brands. The Iodine value of four selected coconut oil brands (C1, C2, C3 and C4) were significantly different ($P<0.05$) while there was no significant difference ($P>0.05$) among the Iodine value of selected commercial palm olein brands. The most commonly available oil brands were selected and purchased in 2 different batches. Then the oil samples were heated at 130±5 ^{o}C for 10 minutes with potato chips for 3 repeated frying cycles. Moisture content, Iodine value, and free fatty acid content were determined after each frying cycle. The moisture content of coconut oil due to repeated deep-frying was significantly increased ($P<0.05$). The iodine value of coconut oil following repeated heating decreased significantly ($P<0.05$) and the Free fatty acid contents of coconut oil samples due to deep-fat frying significantly increased ($P<0.05$). There was no *trans* fatty acid generation in both coconut oil and palm olein due to repeated deep frying up to 3 frying cycles for 10 minutes at 130±5 ^{o}C.

Keywords: Deep frying , Iodine value, Free fatty acid, Trans fatty acid, Frying

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[1]Department of Nutrition, Medical Research Institute, Colombo 08

* pcarampath@gmail.com

Decontamination of Selected Raw Materials Used in Large Scale Food Industries by Using Ultrasound Treated Water and Ozonation

Dasanayaka D.M.I.M., Mendis B.E.P.* and Gunawardana M.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Uncontaminated raw material is of great importance to the food industry in assuring quality and safety of the final product. Ultrasound treatment and ozonation are the newest nonthermal methods used to extend shelf life of raw materials. Both technologies have attracted considerable commercial interest, especially because ozone as well as ultrasound treatments do not leave any residue on the treated produce. The present study was focused to determine the decontamination efficiency of ultrasound and ozone treatments on raw materials used in large-scale food industries. For ultrasound treatment, dried chillies, grapes and leaks were selected as raw materials. Cinnamon quills and desiccated coconut were treated with gaseous ozone and dry chillies, grapes and leaks were treated with aqueous ozone. Food and Hygiene ATP Testing Meter (PCE-ATP I KIT) was used to determine ATP in water and surfaces of raw materials together with total plate count to determine microbial counts. About 60% reduction of surface microbial counts in dried chillies, grapes and leaks was observed after 2 min of ultrasound treatment with 20 kHz. When the cinnamon quills and the desiccated coconut were treated with gaseous ozone (5 ppm) for 20 min, a significant ($p<0.05$) four-fold reduction of the surface microbial counts were observed. The surface microbial counts of cinnamon quills and desiccated coconut were significantly ($p<0.05$) reduced with the treatment of gaseous ozone (5 ppm) up to 20 min. According to the results, it can be concluded that ultrasound treatment and ozonation can be used effectively to reduce microbial counts in raw materials used in food industry.

Keywords: Decontamination, Ultrasound, Ozonation, Raw material, Microbial counts

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[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama

* ereshamendis@agri.pdn.ac.lk

Design and Development of an Intra-Laboratory Capability Validation Program for Hygiene Monitoring by Swab Test

Wijesinghe W.P.M., Prasanna P.H.P.* and Paranagama T.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The knowledge of hygiene monitoring is highly imperative to ensure the safety and quality of food products. The objective of the current study was to develop a simple and precise swab testing method by estimating the recovery percentage of the hygiene swab samples to validate the cleaning procedure of Fonterra brands Lanka (Pvt) Ltd. The swab-testing method was developed for cleaning validation of *Escherichia coli*, Enterobacteriaceae, and Coliform samples collected after artificially contaminating the swabs. The efficiency of this swab testing method was analyzed by estimating the recovery of initially contaminated microbes from the swab surface. Stomaching time and stomaching speed were changed to achieve a better recovery. According to the testing conditions, three different recovery methods were created; stomaching speed 3 for 60 s, stomaching speed 3 for 120 s and stomaching speed 4 for 180 s. The results were analyzed using complete randomized block design and it showed that there was a significant difference among treatments. The results of this study showed that the stomaching speed 4 for 180 s results a higher recovery percentage and it can be used as a validated method for hygiene swab testing.

Keywords: Cleaning, Enterobacteriaceae, *Escherichia coli*, Food Products, Stomaching speed

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[1]Fonterra Brands Lanka (Pvt.) Ltd., No 100, Delgoda Road, Biyagama

* phpprasanna@agri.pdn.ac.lk

Designing and Evaluation of a Small-Scale Mozzarella Cheese Stretcher

Karunarathna M.V.L., Prasanna P.H.P.*, Vidanarachchi J.K.[1], Amarathunga K.S.P.[2] and Jayawaradene L.P.I.N.P.[3]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The pasta filata process of heating with hot water and stretching of Mozzarella cheese curd are typically practiced in production of mozzarella cheese by most of small-scale Mozzarella cheese processors which is a tedious work. Therefore, this study was conducted to design, fabricate and evaluate a cheese stretcher which is suitable for small scale Mozzarella cheese manufacturers. A cheese stretcher was designed and fabricated using locally available materials. The results showed that the stretcher resulted Mozzarella cheese with higher stretch ability compared to the traditional method. The novel cheese starched would be suitable for use in small scale Mozzarella production.

Keywords: Fabrication, Mozzarella cheese, Stretch ability, Twine screw stretcher

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[1]Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
[2]Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya
[3]Aletek International Pvt. Ltd, Ranaviru Prabhath Cooray Mawatha, Rajagiriya
* phpprasanna@agri.pdn.ac.lk

Determination and Comparison of Physicochemical Characteristics of Turmeric Powder (*Curcuma longa* L.) Produced Locally and Imported from Myanmar

Ulpathakumbura B. S. K., Liyanage T.[1*] and Mendis B.E.P.
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Turmeric is a prominent spice, colourant and a preservative agent obtained from dried rhizome of *Curcuma longa* L. Curcumin is the principal component in turmeric, responsible for its reported biological activities. A request has been made by the food industry with a representative turmeric powder sample from Myanmar to grant permission to import and scientific information on its quality is required to provide a recommendation. Department of Export Agriculture monitors the situation to decide on importing turmeric powder based on a comparative analysis of its quality parameters with that of turmeric grown in Sri Lanka. Therefore, this study was conducted to compare the physicochemical characteristics of turmeric powder produced locally and imported from Myanmar. Local samples collected from Kandy, Matale, Kurunagala, Kegalle and Ampara districts were compared with turmeric powder imported from Myanmar for curcumin, volatile oil, total ash, acid insoluble ash, total flavonoid content, colour composition, bulk density and morphology of turmeric powder. The results clearly revealed that there were significant differences ($p<0.05$) in curcumin content and most of the other physicochemical parameters in tested samples. Curcumin percentage of locally produced turmeric powder ranged from 3.90±0.02 to 6.90±0.01. It is evident from results that curcumin content of all local samples comply with the requirements of local standard for turmeric powder. However, curcumin percentage of imported turmeric powder was 1.32±0.04 and it does not meet the specification. The highest content of curcumin, volatile oil and total flavonoid were in the samples collected from Ampara district. Characteristic morphological feature could be identified in turmeric powder, which represents the respective curcumin content. Based on the results of this study, it was concluded that the quality parameters of turmeric imported from Myanmar are substandard compared to that of turmeric powder produced locally, implying that permission should not be granted to importation.

Keywords: Turmeric powder, Curcumin, Myanmar, Physicochemical characteristics

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[1] Department of Export Agriculture, Matale
* thushariphtd@yahoo.com

Determination of Chemical and Nutritional Quality Parameters in Organically and Conventionally Grown Tea (*Camellia sinensis* (L.) Kuntze)

Chamodya K.D.S., Rankoth L.M.* and Hitinayake H.M.G.S.B.
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tea (*Camellia sinensis* (L.) Kuntze) is a popular beverage crop in the world belonging to the family Theaceae. Conventional tea cultivations depend on intensive use of synthetic fertilizers and agrochemicals. In contrast, organically certified and organically managed tea cultivations offer a scope to improve soil quality and the environment. The objective of this study was to evaluate and compare the differences in chemical and nutritional quality of tea green leaves and made tea from certified organic and conventional management systems. This experiment was carried out in smallholder tea lands in Gampola area in Kandy district. Soil pH, EC, total nitrogen, phosphorus, potassium, calcium, organic matter percentage and organic carbon percentage were measured in soils at three different depths (0-10, 10-20, and 20-30 cm). Tea green leaves and black tea were also analyzed for total nitrogen, phosphorus, potassium, calcium, phenols, and total antioxidant concentrations. Soils in the conventional farming system were slightly acidic as compared to organically certified soils. Organically certified tea green leaves showed significantly greater total nitrogen, calcium and total antioxidant concentrations compared to conventional tea green leaves. The organic green tea leaves had 160,048 mmol Fe^{2} l^{-1} of greater total antioxidant level than that of conventional. Total nitrogen, phosphorus, potassium, calcium and total phenol concentrations were also significantly higher in organic black tea compared to conventionally managed black tea with a 647.24 g GA eq l^{-1} of higher phenol concentration in organic tea. When producing black tea from green leaves, total nitrogen, phosphorus, and total potassium concentrations were decreased but total phenol and total antioxidants were increased both in conventional and organically certified tea. The findings from the study may help the tea farming community in deciding the management practices to be applied in their cultivations to produce a better quality product while protecting the environment.

Keywords: Antioxidants, conventional farming, made tea, organic farming, phenols

* lalithrankoth@gmail.com

Determination of Effects of Different Pre-washing Treatments for the Improvement of Quality and Shelf Life of Mechanically Deboned Chicken Meat

Kumarasinghe W.A.K.R., Dissanayake J.K.[1] **and Himali S.M.C.***
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Mechanically deboned chicken meat (MDCM) is mainly produced from chicken parts, which have low economical values. MDCM is a low cost raw ingredient, widely used as a protein source in meat processing industry. MDCM is highly susceptible to lipid oxidation and microbial degradation due to high content of fat & heme pigments and its nature. Various synthetic and natural preservatives can be used to extend the self-life of MDCM. Due to consumer concerns on the potential health hazards associated with dietary intake of synthetic preservatives, the use of herbs as natural preservative agents has gain attention. This study was conducted to evaluate the effectiveness of pre-washing treatments; 2% (v/v) Lactic acid (LA), 8% (v/v) Trisodium phosphate (TSP), 25% (v/v) Turmeric (*Curcuma longa*) extract (TE), 25% (v/v) Ginger *(Zingiber officinale*) extract (GE) on improving the quality and shelf life of MDCM. The 2-thiobarbituric acid reactive substances (TBARS), pH, color, water holding capacity (WHC) values, and microbiological properties of MDCM produced subjected to pre-washing treatments were measured weekly during the storage at -2 °C. The LA pre-wash treatment resulted in the highest reduction of total viable plate count in MDCM ($P<0.05$). TBARS of LA (1.377 mg MDA/kg) and TE (1.532 mg MDA/kg) treated samples were considerably low ($P<0.05$). During storage period WHC and pH were decreased and TBARS was increased. TSP pre-wash resulted MDCM with the highest WHC ($P<0.05$) and the lowest WHC value ($P<0.05$) of MDCM obtained by LA pre-wash. Treatment with TE had highest ($P<0.05$) a* and b* values for color. This study revealed that 2% (v/v) LA pre-washing could be successfully used to improve quality and shelf life of MDCM. As a natural agent pre-washing with TE can result good physiochemical properties of MDCM. Long-term storage analysis of quality attributes of MDCM produced after pre-wash treatments is further recommended.

Keywords: Tri sodium phosphate, Lactic acid, Turmeric, Ginger

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[1]CIC Poultry Processing Plant, Badalgama

* himali.samaraweera@gmail.com

Determination of *In-Vitro* Starch Digestibility and *In-Vivo* Glycemic Index of Selected Newly Improved Rice Varieties

Sarananda H.P.S.M., Wijesinghe D.G.N.G.*, Gunasekara D.C.S.[1] and Madhushanka P.M.V.[2]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

In-vitro starch digestibility and *in-vivo* glycemic index were determined for 7 selected, newly improved rice varieties, namely *Red Nadu, Sudu Suduru, Red Fragrant*, *Black 02, Rathu Suduru, Suwandel* and *White Basmathi*. The glycemic index (GI) and starch hydrolysis percentage of each rice sample were calculated. The GI of rice was determined following the *in-vivo* procedure using 14 healthy individuals aged 20-30 years and body mass index (BMI) of 18-23 kg/m^2. *In-vitro* starch hydrolysis was done using non restricted incubation with the amylase enzyme followed by colourimetric analysis of glucose to estimate the hydrolysis index (HI) of starch. The proximate composition of rice was determined following the Association of Analytical Chemists official methods 2000. The amylose content and total available carbohydrate content of rice were determined using the iodine colourimetric method and phenol sulphuric method, respectively. Pearson correlation coefficient was used to identify the association between *in-vivo* GI and *in-vitro* HI of tested rice varieties. The relationship between proximate composition and amylose content with the HI was also studied. According to the GI classification, *Rathu Suduru* (72.9±17.8) belonged to high GI, *Black 02* (51.4±17.8) and *Red Fragrant* (51.0±07.0) belonged to low GI and all other tested rice varieties (*Sudu Suduru, Red Nadu, White Basmathi, Suwandel*) belonged to medium GI (56-69). A significant positive correlation ($r=0.929$; $p<0.05$) was obtained for the HI at 120 min and GI value of rice. The relationship between HI and protein content and HI and amylose content of rice was weak. In conclusion, HI could be recommended for the screening of rice varieties to be classified under three broad GI categories, low, medium and high.

Keywords: Rice, Glycemic index, Hydrolysis index, *in-vivo* GI, HI

[1]CIC Dairies (Pvt) Ltd., Ibbankatuwa, Dambulla
[2]CIC Agribusiness (PVT) Ltd, Pelwehera, Dambulla
* wijeng@yahoo.com

Determination of Sterilization Value (F_o) and Predict the Shelf-Life of Canned Young Jackfruit (*Artocarpus heterophyllus* L.)

Dineshika E.G.U., Prasantha B.D.R.*, Yatiwala S.[1] and Chandrasiri K.A.K.L.[2]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Canned young jackfruit is a product made out of young jackfruit pieces by pre-treating with citric acid. The aim of this research was to predict the shelf-life and determine the sterilization value (F_o) of canned jackfruit after commercial sterilization process. The shelf-life was predicted by the accelerated shelf-life test method using the Arrhenius model. The F_o values of the heat resistance anaerobic *Clostridium botulinum* and *Clostridium sporogenes* were used to assess the commercial safety level of the sterilization process of canned jackfruit samples. After the sterilization, cans of young jackfruit samples were stored in 27 °C, 45 °C and 55 °C for 30 days to evaluate the pH, acidity, total plate count (TPC), yeast and mould, texture and colour in every week. Based on the Arrhenius model, change in TPC, acidity, texture follows the zero-order reaction while pH follows the first-order reaction. The change in TPC was used to predict the shelf-life in terms of microbial safety. Based on TPC, predicted shelf-life of canned jackfruit sample range between 21.6 and 41.6 months. The calculated F_o value was significantly greater ($p<0.05$) than the standard F_o values 2.28 and 15.36 min of *Clostridium botulinum* and *Clostridium sporogenes*, respectively. Therefore, the current time-temperature level was sufficient enough to attain the commercial microbial safety of the canned jackfruit sample.

Keywords: Shelf-life , Sterilization value, Arrhenius model, Accelerated shelf life testing

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[1]HJS Condiments Limited, Biyagama

[2]Department of Food Science & Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya

* rop_bd@yahoo.com

Determination of the Effect of Different Stabilizers/Emulsifiers on Physico-chemical Parameters of Peanut Butter

Mathukeerththana V., Jayanath N.Y.* and Rasakanthan K.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study aimed at evaluating the effects of different stabilizers/emulsifiers on physico-chemical parameters of peanut butter. Different formulations of peanut butter were prepared by changing stabilizers/emulsifiers (guar gum, Palsgaard® oil binder 01, Palsgaard® 6111, lecithin and soy lecithin) and their concentration (0.3%, 0.5% and 0.7%). Oil holding capacity of prepared peanut butter was determined by centrifugation, after 72 hours of storage. Formulations of Peanut butter were evaluated for changes in physico-chemical parameters including moisture content, oil separation percentage, colour and viscosity over 3 weeks of storage at room temperature. Three formulations having higher oil holding capacities were tested for organoleptic acceptance using a hedonic test. Oil holding capacity was significantly affected by stabilizer/emulsifier type ($p<0.05$) but the level ($p>0.05$). Stabilizer/emulsifier type, their levels and storage time did not show any significant effect ($p>0.05$) on moisture content and viscosity of different formulations. Oil separation percentage was significantly affected ($p<0.05$) by stabilizer/emulsifier type and storage time but the level of stabilizer/emulsifier ($p>0.05$). The highest oil separation recorded was 1.80% after three weeks of storage for formulation prepared with 0.7% of lecithin. Palsgaard® oil binder 01 and Palsgaard® 6111 were selected as the best stabilizers in terms of oil separation. Colour of the formulations significantly ($p<0.05$) affected by stabilizer/emulsifier type in terms of L* and a* value, but b* value ($p>0.05$). Results of the sensory analysis showed that preference of colour did not show any significant difference ($p>0.05$) among the selected formulations containing 0.3% of Palsgaard® 6111, 0.5% of Palsgaard® 6111, and 0.3% of lecithin, but preference for aroma, flavour, and overall acceptability was significantly different ($p<0.05$). Formulation with 0.3% of Palsgaard® 6111 obtained higher consumer preference than other two formulations considering the tested sensory attributes.

Keywords: Emulsifier, Oil separation, Peanut butter, Physico-chemical parameters, Stabilizer

[1]North Lanka Family Foods (Pvt.) Ltd., Killinochchi

* jayanath11@gmail.com

Determination of the Effect of Freezing Methods on the Quality of Frozen Carrot (Cape market variety) Dices and Tomato (Thilina & RIDA Fl varieties) Pieces

Rikasa A.M., Senarathne S.M.A.C.U.[1] **and Wimalasiri K.M.S.**[*]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Due to highly perishable nature, vegetables possess a higher chance of deterioration and damage after harvesting. In Sri Lanka, a substantial quantity of vegetables are wasted daily due to this problem. Among the vegetables, especially carrot and tomato have a wide range of usage and demand in different sectors. Freezing is a potential preservation technique used to reduce the deterioration and increase the shelf life of those vegetables. In this research physio-chemical and sensory parameters of carrot dices (*Cape market* variety) and tomato pieces (*Thilina* and *RIDA F1* varieties) were analyzed under blast freezing (-30 ^{o}C) and conventional freezing (-18 ^{o}C) conditions. Both freezing methods preserved the chemical parameters of vegetables. The blast frozen-thawed vegetables showed the best quality than the conventional frozen-thawed vegetables. The preference for the blast frozen carrot dices and tomato pieces were significantly ($p<0.05$) higher than the conventional frozen samples with respect to sensory parameters.

Keywords: Tomato, Carrot, Blast freezing, Conventional freezing, Shelf life

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[1]Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya

* swarnaw@agri.pdn.ac.lk

Developing Oat Incorporated Gelatin-Free Drinking Yoghurt and Assessing its Probiotic Activities

Kumara D.S.W., Wijesinghe D.G.N.G.* and Gunasekara D.C.S.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The aim of this study was to develop oat incorporated gelatin-free drinking yoghurt and to assess its probiotic activities. Probiotics, prebiotics and synbiotics are the generally used terms when discussing about functional dairy products. At present, mostly used commercial probiotic strains are Lactobacillus spp. and Streptococcus thermophilus and they are incorporated to the starter culture of fermented dairy products. When prebiotic materials are considered, the demand for natural additives has increased worldwide. Oat is a nutritious and dietary fiber rich cereal having prebiotic and natural stabilizing properties. Drinking yoghurts were prepared incorporating four levels (0, 1, 2 and 3%) of oat replacing skimmed milk powder in the formula and their physicochemical, rheological and microbiological properties were determined for a storage period of four weeks to examine their stability and the probiotic counts. Sensory analysis was done to identify the most consumer-preferred product and the nutritional composition was also analysed. The data were analysed using one-way ANOVA, Turkey's test and Friedman's test. Microbiological, physicochemical and rheological test results revealed that oat incorporation has improved all above properties in the drinking yoghurt. Escherichia coli or mold was not detected in the oat incorporated drinking yoghurts, and the yeast count was within the acceptable limit (maximum 1×10^3 CFU/g), during the storage period. According to the sensory panel, 2% oat (w/w) incorporated drinking yoghurt showed the highest sensory attributes. Crude fat content and crude fiber content had a significant ($p<0.05$) positive relationship while moisture, ash and crude protein contents had a significant ($p<0.05$) negative relationship with oat incorporation. According to overall results, it can be concluded that gelatin-free, prebiotic drinking yoghurt containing 2% oat (w/w) can be developed with acceptable physicochemical and sensory properties. The product can be safely stored for four weeks at 4 ^oC.

Keywords: Probiotics, Prebiotics, Oat, Stabilizing properties, Probiotic activities

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[1]CIC Dairies (Pvt) Ltd., Ibbankatuwa, Dambulla

* wijeng@yahoo.com

Development and Analysis of Quality Characteristics of Kithul Flour and Palmyrah Tuber Flour Incorporated Cake

Balasooriya L.B.C.R.D., Udayakumara E.M.S.[1] **and Prasantha B.D.R.***
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was aimed to develop a value-added cake by incorporating Kithul and Palmyra tuber flours. Three different ratios of Kithul flour and Palmyra tuber flour were mixed with 20 g of wheat flour to develop new cake formulations (C1, C2, and C3 total of 100 g). The developed three formulations and control were tested for batter characteristics in terms of bulk density, batter temperature, batter pH, and baking time and tested for physico-chemical characteristics in terms of cake pH, moisture content, height, surface area/volume ratio, and weight. Moisture content and pH of the cake samples were tested for 20 days of storage at 30±2 °C. Consumer preference of the formulations was tested using the ranking test. According to the sensory evaluation, Kithul and Palmyra flours incorporated C1 cake formulation was accepted as the best treatment with the highest consumer preference. The pH of the C1 treatment and control was increased up to 10 days and then decreased with storage time and moisture content of the C1 treatment and control was decreased with the storage time. The study suggested that Kithul flour and Palmyra tuber flour incorporated cake can be developed with better consumer preference.

Keywords: Kithul flour, Palmyra tuber flour, Cake, Development

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[1]Little Lion Associates (Pvt) Ltd, Colombo

* rop_bd@yahoo.com

Development of a Chicken Drumstick Vegetarian Analogue and Determination of Its Physico-Chemical Properties

Mallawaarachchi M.A.N.S., Rajapakse R.P.A.D.[1] **and Rajapakse R.P.N.P.***
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was aimed to develop a chicken drumstick vegetarian analogue having authentic fibrous and tender meat texture, using locally available raw materials. Tender jackfruit (*Artoarpus heterophyllus*), *kohila (Lasia spinosa)* rhizome and chickpea flour were used as the main ingredients. Four formulations from the above raw materials were prepared with different spices to match with the authentic meaty flavor. The best formulation was selected following different physico-chemical tests (pH, color, water activity, shrinkage, batter pickup, oil usage, and cooking loss) and compared with the real chicken drumstick as the control. Sensory ranking tests were performed to study the consumer preference for texture, flavor and overall acceptability of the formulations. The results of physico-chemical tests revealed that all four formulations were not significantly different ($p>0.05$) for before frying pH, after frying lightness (L*) and yellowness (b*) and batter pickup compared to the control. Real-time shelf-life determination revealed that the product was self-stable under frozen condition showing no significant impact ($p>0.05$) on packaging system (normal sealed package and vacuumed seal package), in terms of microbial quality, color, cooking loss and pH for the 15-day study period. Based on the calculated Q_{10} value (2.06) of accelerated shelf life study, it was revealed that the product was self-stable for 56 days under frozen condition without added preservatives, in terms of microbial quality. Moisture, crude protein, crude fat, crude fiber and ash content of the final product were 66.79 ± 0.03%, 7.31 ±0.10% 5.79 ± 0.07%, 4.88 ± 0.07% and 2.63 ± 0.08%, respectively. Further research is needed to improve the protein content of the developed product, similar to real chicken drumstick.

Keywords: Chicken drumstick, Meat analogue, Storage stability, Physico-chemical properties

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[1]HJS Condiments Limited Block 61, 62 & 63 Biyagama Export Processing Zone (B.E.P.Z)

* n_rajapakse@yahoo.com

Development of a Citrus Fiber Incorporated, Milk Enriched Whey-Based Fermented Drink

Weerasinghe W.M.S.D., Prasanna P.H.P.*, Vidanarachchi J.K. and Jayawardene L.P.I.N.P.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Whey disposal is a major problem in cheese processing. However, it has not been effectively used in food industry due to expensive methods involved in whey processing. This study was aimed to develop a whey-based drink using the sweet whey enriched with milk. Citrus fiber was added with the aim of improving the texture and flavor characteristic of the beverage. Whey beverage was prepared using whey: milk ratios of 1:1 and 5:3, respectively with and without citrus fiber. The fermentation was carried out using traditional yoghurt cultures. The storage stability of the beverage samples was tested for 21 days at 4 °C. Physicochemical parameters, microbiological stability and sensory attributes of the products were evaluated. The results revealed that pH of all the treatments was decreased recording an increase of acidity level of all formulations with the storage. Yeasts and mould were not found for 14 days of storage in any formulation. According to the sensory evaluation, the beverage produced with whey: milk ratio of 5:3 with citrus fiber was accepted as the best treatment with the highest consumer preference. The results of this study suggested that citrus fiber could be used to improve physicochemical and sensory attributes of milk enriched whey-based fermented drink.

Keywords: Flavor, Fermentation, Traditional yoghurt cultures, Sweet whey

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[1]Aletek International Pvt. Ltd, Ranaviru Prabhath Cooray Mawatha, Rajagiriya

* phpprasanna@agri.pdn.ac.lk

Development of a Dog Food Based on Pharmaceutical By-product Gelatin

Hegoda P.R. and Himali S.M.C.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was designed to develop a gummy like textured dog food by using pharmaceutical by-product gelatin (PBG), poultry by-product meal (PBM) and *Gotu kola* (*Centellaasiatica*). Eight types of different dog food processing trials were conducted by using different percentages of above-mentioned raw materials to select the most suitable gummy like textured dog food. The selected dog food formulation was composed of 90% of PBG, 8% of PBM and 2% of *Gotu kola* (*Centellaasiatica*).The processing of dog food involved melting of PBG by using a hot plate and addition of mixture of PBM & *Gotu kola* (*Centellaasiatica*) and boiling it for approximately 4 min. Then the mixture was poured into moulds and allowed for cooling at room temperature. The proximate composition, pH, and microbiological analyses of the dog food were carried out. A feeding trial was conducted with 4-5 month old dogs to assess the palatability and the digestibility of the dog food. According to the proximate composition of the selected dog food, moisture content, crude protein (CP) and crude fat (CF) contents were 16.27±0.41%, 75.33±0.12% and 3.51±0.55%, respectively. The pH and total variable aerobic plate countschanged during the storage period significantly ($P<0.05$). The dog food was free from coliform. The palatability of prepared dog food was very high as the dog consumed all daily allowance of the pet food very fast. The digestible crude protein value of selected dog food was 82.64%±1.76. The selected dog food is highly acceptable to dogs and it has a high digestibility. The pet owners can use it as a dog treat.

Keywords: By-product, Dog treat, Gelatin, Gotu kola, Gummy

Authors are grateful to Bio Extracts (Pvt) Ltd (Baraka), Colombo, Farm's Pride (Pvt) Ltd, Gambol and Taker Trust Animal Care Centre, Kandy for their generous contributions made in carrying out the research.

* himali.samaraweera@gmail.com

Development of a Field Kit and a Color Chart to Estimate In-situ Soil Organic Matter and Total Nitrogen

Dehipola M.G.S.R. and Nandasena K.A.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Organic matter is an important component of a fertile agricultural land. Generally, soil organic matter (SOM) and total nitrogen (N) are determined by Walkley and Black method and Kjeldahl determination, respectively. These are laborious and time consuming methods. A simple procedure instead of the widely-used method is valuable for analyzing SOM. A simple colorimetric procedure had been developed for analyzing SOM and proven to be more promising. The objectives of this study were to develop a field-kit using the colorimetric procedure, and to estimate SOM and soil total N contents, in-situ. Thirty-eight soil samples collected from different regions of Sri Lanka were used in the analysis. Titrimetric organic matter contents were determined by Walkley and Black method and colorimetric organic matter contents were estimated by using UV-visible spectrophotometer at 600 nm. Total N contents were determined by Kjeldahl method. The correlation between the two methods of determining SOM, and the correlations between total N % and colorimetric SOM were analyzed. A strong regression relationship (R^2= 0.981) was observed between colorimetric and titrimetric SOM contents. There was a strong relationship (R^2=0.826) between the colorimetric SOM and total N contents. A standard series was prepared using sucrose to represent 0, 0.5 %, 1 %, 1.5 %, 2 %, 2.5 %, 3 %, 3.5 %,4 %, 4.5 %, 5 % of organic matter contents. A color chart was developed using the standard series to highlight the respective organic matter contents. The regression equation was mentioned in the color chart to enable prediction of N contents in soils. A portable field-kit was developed with simple instruments and chemicals.

Keywords: Color chart, Colorimetric, Soil organic matter, Titrimetric, Total nitrogen

* nandasenakalahe@gmail.com

Development of a Herbal Syrup from Costus igneus Leaf Extract & Investigation of its Antidiabetic& Antioxidant Properties

Thuraisingam M., Jayanath N.Y.* and Selvaluxmy C.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was aimed to develop a herbal syrup having antioxidant and antidiabetic potentials using a hot water extract of *Costus igneus*(CI) leaves. Leaves were dried, powdered and stored in air-tiedcontainers until used. The dried powder was analyzed for its moisture content, total ash content (TAC), acid insoluble ash content (AIAC) and water-soluble ash content (WSAC). Presence of alkaloids, saponin, flavonoids, terpenoids, tannin, steroids and cardiac glycosides in the powder was identified while alkaloid and saponin levels were quantified. The dried powder was extracted using hot water at 40 °C for 4 h. Syrup formulation was prepared with different excipients. Both the syrup and the extract were subjected to different antioxidant assays. Antiamylase activity of the syrup was determined. Moisture content, TAC, AIAC and WSAC of the dried powder were 43.31±0.16, 14.5±0.24, 0.16±0.43 and 0.11±0.86% respectively. The powder was found to be positive for all the tested phytochemicals with 10.01 mg/g of alkaloids and 24.35 mg/g of saponins. The organoleptically accepted formulation was developed by mixing the excipients of methylcellulose, sorbitol, glycerine, lime solution and benzoic acid with the CI extract. Total phenolic content (TPC) and total flavonoid content (TFC) of the extract were found to be 210.6±0.25 mg gallic acid equivalents/L and 148.63±0.12 mg quercetin equivalents/L respectively while values for the syrup were found to be 75.74±0.06 mg gallic acid equivalents/L and 68.38±0.106 mg quercetin equivalents/L respectively. The developed syrup showed an anti-amylase activity with an IC_{50} value of 740.10±0.28 mg/L.

Keywords: Antidiabetic activity, Antioxidant activity, *Costus igneus* leaves, Herbal syrup, Phytochemicals

[1]Industrial Technology Institute, Malabe

* jayanath11@gmail.com

Development of a Spice Infused Beverage Series Using Mature Coconut Water (*Cocos nucifera*)

Wanniarachchi W.A.K.T.M., Arampath P.C.* and Dissanayake S.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Mature coconut (*Cocos nucifera*) water is a nutrient rich industrial by-product enriched with significant physico-chemical properties and therapeutic properties. The objective of the research was to develop a series of spice infused beverages using mature coconut water with ginger (*Zingiber officinale*), cardamom (*Elettaria cardamomum*), clove (*Syzygium aromaticum*), cinnamon (*Cinnamomum verum*), turmeric (*Curcuma longa*) and black pepper (*Piper nigrum*). A ready to drink (RTD) beverage series was formulated ensuring consumer acceptability. Spices were selected based on nutritional and functional properties. Individual spices and spice mixture were incorporated at, cardamom and clove 0.1,0.2,0.3,0.4,0.5 g/dm^3, cinnamon and spice mixture 0.2,0.4,0.6,0.8,1 g/dm^3 and ginger 0.25,0.5,0.75,1,1.25 g/dm^3. The most suitable treatments were selected using sensory evaluation of colour, aroma, flavour and overall acceptability on 7 point Hedonic scale. Selected formulations were evaluated for physico-chemical properties, microbiological safety and functional compounds. Selected concentrations were 0.3 g/dm^3 of clove (colour = 5±0.4, aroma = 5.7±0.6, flavour = 5.2±0.54, overall acceptability = 5.3±0.61), 0.4 g/dm^3 of cardamom (colour = 5±0, aroma = 5.9±0.48, flavour = 5.45±0.56, overall acceptability = 5.25±0.54), 1 g/dm^3 of ginger (colour = 5.2±0.14, aroma = 5.4±0.58, flavour = 6±0.83, overall acceptability = 6±0.62), 0.8 g/dm^3 of cinnamon (colour = 5±0, aroma = 5.3±0.47, flavour = 6±0.45, overall acceptability = 5.6±0.59) and 0.6 g/dm^3 mixed spice (ginger, cardamom, clove, cinnamon, turmeric and black pepper) (colour = 5±0.5, aroma = 5.9±0.96, flavour = 5.5±0.54, overall acceptability = 6±0.5). The developed beverage series comply with the FDA standards for TSS (6.5±0.1 ^{o}Brix), pH (4.5±0.06) and microbiological limits (<5000 CFU/ml of TPC). The developed spice infused beverages possess potential commercial value for export trade.

Keywords: Cinnamon, Fat separation, Pasteurization, Ready-to-drink, Sensory evaluation

[1]Nutible Treeler (Pvt.) Ltd, Colombo 08, Sri Lanka

* pcarampath@gmail.com

Development of an Instant Coffee Mix with *Moringa oleifera* Leaf Powder and Investigation of Its' Physico-chemical and Sensory Properties

Wickramasekara E.D.C., Lakmali K.M.[1] **and Samarakoon E.R.J.**[*]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Instant beverages are one of the most popular instant products among consumers and development of instant beverages with health benefits has a great potential in the local and international market. Moringa has gained attention of many researchers as Moringa leaves are rich in vitamins, minerals, essential amino acids and antioxidants. Therefore, the objectives of this research project were to develop an instant coffee mix with *Moringa oleifera* leaf powder and investigate the physico-chemical properties, sensory attributes and the antioxidant potential of the developed product. In brief, research project consists of optimization of the hot water extraction of *Moringa oleifera* dried leaf powder, preparation of extract based on the optimized conditions, obtaining freeze dried powder, sensory evaluation for the selection of sweetener and creamer, development of the formulation and assessment of the physico-chemical properties, sensory attributes and the antioxidant potential. Optimized conditions for hot water extraction were 60 °C of extraction temperature, 25 minutes of extraction time and 1:10 ratio of dry Moringa powder:water with the maximum total phenolic content, total soluble solid and yield values were 95.92 mg GAE (Gallic Acid Equivalents)/g of powder, 3.25 Brix and 0.28 g/g of dry powder, respectively. Preference for sugar as the sweetener and milk powder as the creamer were significantly different ($p<0.05$) with respect to sensory attributes. Ingredients of the products were Moringa leaf extract powder, instant coffee, sugar and the milk powder. The formulations which contained 2.5 and 5% of Moringa extract powder were the best formulations with respect to the physico-chemical properties, sensory attributes and the total phenolic content.

Keywords: Antioxidants, Instant beverages, *Moringa oleifera* leaf powder, Sensory evaluation

[1]HJS Condiments Limited, Biyagama

* rasanjalis@agri.pdn.ac.lk

Development of Bio-Composite Packaging Material as an Alternative for Plastic Yoghurt Cup Using Agricultural Waste Fillers and Ethylene Vinyl Acetate Water-Based Co-Polymer Emulsion

Kularathna H.M.T.P, Prasanna P.H.P.*, Vidanarachchi J.K., Karunarathna A.K. and Jayawaradene L.P.I.N.P.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Set-yoghurt is a one of most popular and highly nutritious fermented dairy product in Sri Lanka. In the present situation, petroleum-based polymers are mainly used as the packaging material for yoghurt. However, these petroleum-based plastics are non-biodegradable and lead to critical global socio-environmental issues. Therefore, this study was conducted to invent and produce a bio-composite packaging material for set-yoghurt using agricultural wastes as the filler of composites namely groundnut shell powder (GSP) and corn cob powder (CCP). Ethylene vinyl acetate (EVA) water-based copolymer emulsion was used as the matrix of the composites. The filler-matrix mixing ratios were determined by using a preliminary study. The selected mixing ratio of CCP: EVA and GSP: EVA were 1: 2.5 and 1: 2, respectively (w/w). Both GSP and CCP were used in three types as non-treated, hot-water treated (boiled) and NaOH treated resulting six types of composites as:T1 (non-treated CCP-EVA composite), T2 (hot-water treated CCP-EVA composite), T3 (NaOH treated CCP-EVA composite), T4 (non-treated GSP-EVA composite), T5 (hot-water treated GSP-EVA composite) and T6 (NaOH treated GSP-EVA composite). The tensile strength, density and water absorption of different composites were tested. The results of tensile strength test showed that the average ultimate tensile strength (UTS) of composites ranged between 0.467 MPa to 0.897 MPa. NaOH treated GSP-EVA composite resulted the maximum average UTS of 0.897 MPa ($P < 0.05$). The water absorption test results showed that average water absorption of cheese wax coated different composites ranged from 0.29% to 45.84%. Density property test results showed that average density of composites ranged between 0.897 g cm^{-3} to 1.123 g cm^{-3}. The results of this study suggested that NaOH treated groundnut shell powder-EVA composite could be used to produce a biodegradable packaging material for set-yoghurt.

Keywords: Bio-composite, Corn cob powder, Ethylene vinyl acetate, Filler, Groundnut shell powder

[1]Aletek International Pvt. Ltd, Ranaviru Prabhath Cooray Mawatha, Rajagiriya

* phpprasanna@agri.pdn.ac.lk

Development of Edible Dessert Cup Using Banana Blossom Powder

Ishara W.A.K.S. and Arampath P.C.*
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Banana is a well-known fruit and the second fruit crop in the world. In Sri Lanka it is the most widely cultivated and consumed fruit. Two varieties, embul and seeni kesel, which belonged to Mysore bananas, are widely consumed in our country. Though the fruit has a high economic value, the banana blossom is considered as an underutilized agricultural commodity. It is a good source of both macro and micro nutrients. Banana blossom powder has a high potential for substitution in bakery products as an ingredient. The aim of the research was to develop banana blossom powder incorporated edible dessert cups as an effective alternative to plastic dessert cups. Developed edible cups were produced with desired sensory attributes and high amounts of nutrients. Five formulations incorporating 25%, 35%, 45%, 55% and 65% of banana blossom powder from both embul and seeni kesel varieties were prepared and the 35% incorporation of seeni kesel banana blossom powder was selected as the best product using the consumer oriented sensory test. The proximate composition of the final product in dry basis was 2% moisture, 2.3% ash, 7.7% crude protein, 23.3% crude fat and 12.1% crude fibre. The developed cup was a rich source of fibre. Each dessert cup weighing 50 g, contains 140 mL, with dimensions 4 cm height, 9 cm outer diameter, 3 mm wall thickness, 103.60 N hardness and 0.816 J compression energy. The cup contains relatively very low water activity (0.32) and the total plate count ($<10^6$ CFU/g) and yeast and mold count ($<10^2$ CFU/g) were below maximum permitted levels of FDA after two weeks. Further incorporation of banana blossom powder reduces the lightness, hardness and increases the color intensity of the final product.

Keywords: Banana blossom powder, Incorporation, Sensory test, Proximate composition, Fibre

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* pcarampath@gmail.com

Development of *Manihotesculenta crantz* (Cassava) Starch Based Biodegradable Food Packaging Material with Eggshell and Cellulose Fillers

Karunadhipathi U.L. and Himali S.M.C.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

In recent years, biodegradable materials have attracted increasing concern due to their wide applications in food packaging. These eco-friendly polymers replace the usage of petroleum-based synthetic polymers due to their safety, inexpensiveness, and biodegradability.The main objective of this study was development of biodegradable food packaging material. At the initial stage,the best starch source was selected from Cassava, Green taro, Eggfruit, and Jackfruit seeds. Then in the second stage best eggshell powder incorporation level was selected with the selected starch source in the first stage. Two types of bioplastics were developed with selected starch source and selected eggshell incorporation level with two cellulose fillers namely paper pulp (PP)and ground paddy husks (PH). Mechanical properties, water absorption, and biodegradability of bioplastics were determined to select the best cellulose filler among PP and PH. According to the results obtained from the preliminary study among 4 different starch sources,Cassavastarch was selected as the best starch source. Results from the second study revealed that 12% of eggshell powder incorporation was the best. According to the results obtained from the third study, thickness and tensile strength values of 2 types of bioplastics were not significantly different($P>0.05$).But PP based bioplastic showed significantly higher ($P<0.05$) Young's modulus value (76.833 MPa) than the PH based bioplastic (42.886MPa). The biodegradability of 2 types of bioplastics was not significantly different($P>0.05$). But both bioplastics totally biodegraded within 9 weeks. Then PH based bioplastic had a significantly high ($P<0.05$) water absorption (32.83%) than PP based bioplastic (11.47%). These results indicated that PP based bioplastic (12% Cassavastarch,12% Eggshell, 5% PP, 63% Water, 3.5% Acetic acid, 4.5% Glycerol)is better than PH based bioplastic for the development of biodegradable food packaging material.

Keywords: Biodegradability, Bioplastics, Paddy husks, Young's modulus

* himali.samaraweera@gmail.com

Development of Milk Incorporated Instant Dry Noodles

Perera S.S.A., Deshapriya R.M.C.* and Madhujith W.M.T.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The objective of this study was to develop milk incorporated instant noodles using wheat flour as the base and fresh milk (FM), whole milk powder (WMP), and skim milk powder (SMP) at different ratios to obtain desired physico-chemical and organoleptic attributes. In noodle formulation, FM (10, 20, and 30%, w/w), water (4:36, 8:32, 12:28), milk powders (4, 8, and 12%, w/w) and wheat flour (4:96, 8:92, 12:88) were used. The most acceptable combination of each component was determined through a sensory evaluation. The most preferred combination was FM (10%), WMP (8%) and SMP (8%). The control noodles sample was formulated using wheat flour (71%), water (28%) and salt (0.7%). The physico-chemical parameters such as moisture, ash, crude protein, crude fat and available carbohydrate contents together with energy, cooking time, total solids in gruel, and the swelling index were estimated for all the selected noodle samples. Milk powder incorporated noodles showed a significantly ($P<0.05$) higher amount of ash than control and FM incorporated noodles. Moisture content (6.36±0.04%, w/w) and energy (16.53±0.11 KJ/g) were not significantly different ($P>0.05$) among noodle samples. Available carbohydrate (75.79±0.37%, w/w) of WMP incorporated noodles was significantly ($P<0.05$) lower than that of other products. Crude fat (2.90±0.19%, w/w) of WMP incorporated noodles was significantly higher ($P<0.05$) than that of other products, however, the crude protein of both control (13.49%) and FM (13.68%) incorporated noodles was significantly higher ($P<0.05$) than those of FM (12.38%) and SMP (12.59%) incorporated noodles. Total solids in gruel and swelling index of milk powder incorporated noodles were significantly ($P<0.05$) higher than those of the control and FM incorporated noodles. The cooking time of milk incorporated products was significantly ($P<0.05$) higher compared with control. It is concluded that WMP 8% incorporated noodle is a nutritionally superior product.

Keywords: Instant dry noodle, cow milk, wheat flour, physicochemical properties

[1]Department of Food Science & Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya

* desha1018@yahoo.com

Development of Omega-3 Enriched Chicken Sausage Using Commercially Available Omega-3 Concentrates by Applying Microencapsulation Principles

Elagalla K.A.E.A.S., Gunawardana M.[1] **and Himali S.M.C.***
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was carried out to obtain a value-added sausage, which is enriched with Omega-3 polyunsaturated fatty acids (PUFAs) at a low cost of production. Commercially available Omega-3 concentrates (OC) were used as the Omega-3 source. The total oil requirement was partially substituted with OC (41.42%) of the sausage fat emulsion. Substitution was done in two ways; addition of substituting amount of OC directly to the fat emulsion (Treatment 1) and addition of substituting amount of OC as microcapsules (Treatment 2). Isolated Soy Protein (ISP), OC, water, tocopherol, and egg yolk were the ingredients used for microencapsulation in T2. Ingredients were homogenized for 3 minutes at 100 rpm using laboratory homogenizer. Rest of the sausage production was similar to normal procedures. Two treatments were compared with the control sausage sample (C) for proximate composition, pH change, colour change, TBARS value change, and the microbial quality change. Sensory evaluation was conducted with thirty untrained panelists. Protein and ash contents were higher ($P<0.05$) in T2 when compared to C and T1. pH, colour and TBARS changes of T1 and T2 were significantly different ($P<0.05$) from the C. Microbial quality did not show a significant difference among C, T1, and T2. Colour, juiciness, aroma and, taste of C were more preferred by the panelists ($P<0.05$) over T1 and T2. Therefore, addition of substituting amount of OC as microcapsules was not succeeded in enriching chicken sausage with Omega-3. Addition of substituting amount of OC directly to the fat emulsion was effective when compared with the modified method.

Keywords: Omega-3 PUFA, Emulsion, Homogenization, Microcapsules

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[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama

* himali.samaraweera@gmail.com

Development of Residual Lactose Free Drinking-yoghurt Through Lactose Hydrolysis

Jayasinghe J.S.C.K., Vidanarachchi J.K.*, Prasanna P.H.P. and Jayawardene L.P.I.N.P.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The aim of this study was to develop residual lactose free drinking-yoghurt especially for the consumers having lactase deficiency. A preliminary study was conducted to determine the most suitable level of enzyme out of 7 levels (0.025%, 0.050%, 0.075%, 0.1%, 0.2%, 0.3% and 0.4%) of lactase (NOLA Fit 5500) with recipe 01. In the secondary study, the recipe 2 was used for further development of the residual lactose free drinking-yoghurt with 3 different lactase levels such as 0.025%, 0.050%, 0.075% (w/w). In the secondary study, drinking-yoghurt samples were analyzed for chemical, microbiological and organoleptic properties. Chemical (residual lactose content and titratable acidity) and microbiological properties were measured in drinking-yoghurt samples at 0, 7, 14 and 21 days of storage at 4°C. Percentages of total solids, ash, fat and crude protein in drinking-yoghurt samples were not changed considerably ($P>0.05$) with the levels of lactase. Sensory evaluation of the study revealed that the treatment containing 0.075% (w/w) of lactase enzyme was much preferred ($P<0.05$) by the panelists. Residual lactose content and titratable acidity of samples prepared with 0.075% of lactase enzyme were zero and 0.51% lactic acid, respectively at 21 days. This study revealed that 0.075% (w/w) of lactase (NOLA Fit 5500) enzyme could be successfully utilized to manufacture residual lactose free drinking-yoghurt with better chemical, microbiological and sensory properties.

Keywords: Drinking-yoghurt, residual lactose, lactase enzyme, lactose hydrolysis

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[1]Aletek International Pvt. Ltd, Ranaviru Prabhath Cooray Mawatha, Rajagiriya

* janakvid@pdn.ac.lk

Dietary Protein Intake and Days in Milk Influence on the Milk Urea Nitrogen, Non-Esterified Fatty Acids and β-Hydroxybutyric Acid Content in the Different Production Categories of Milking Cows in a Hill Country Farm, Sri Lanka

Premachandra H.G.B.S., Vidanarachchi J.K.*, Mangalika U.L.P.[1], Senarathne P.[2], Kumara Mahipala M.B.P. and Kodithuwakku S.P.
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Milk urea nitrogen (MUN) content, serum metabolites and nutritional status of temperate Friesian × Jersey crossbred cows at early, mid and late-lactation stages of a large-scale farm in the Up-country, Sri Lanka were assessed through using spectroscopic method and serum metabolic profile analysis, respectively. Nutritional values of the total mixed rations (TMR) of different production categories were analysed. Days in milk, body weight and milk production of cows were recorded. Somatic cell counts of milk samples were measured using a DeLaval somatic cell counter. Cows that produce milk with over 2×10^5 somatic cells/mL were identified as at least sub-clinically mastitis infected cows and those cows were eliminated from the study. Cows were bled through caudal vein and serum samples were analysed for non-esterified fatty acids (NEFA) and beta-hydroxybutyrate (BHBA) contents. Levels of MUN and serum metabolites (NEFA and BHBA) were compared with respective critical limits of reference ranges proposed to assess the protein and energy status in dairy cows. Serum NEFA and BHBA contents recorded in temperate Friesian × Jersey crossbred cows examined in the present study at early-lactating (0.20±0.03, 0.595±0.176 mmol/L), mid-lactating (0.19±0.04, 0.495±0.120 mmol/L) and late-lactating (0.24±0.10, 0.414±0.201 mmol/L) stages suggested that cows were not in the state of negative energy balance. Average MUN contents of the cows at early-lactation (22.6±3.3 mg/dL) and mid-lactation (22.9±1.6 mg/dL) stages were lower than the upper critical limit (25 mg/dL) of the reference range. The average MUN content (26.1±4.0 mg/dL) of the cows at late-lactation was higher than the upper critical limit (25 mg/dL) of the reference range. Adaptation of appropriate feeding strategy particularly focusing to overcome the protein imbalance is warranted to optimize the production of Jersey x Friesian crossbred cows in the studied farm.

Keywords: Friesian × Jersey, MUN, NEFA, BHBA, negative energy balance

[1]Veterinary Research Institute, Gannoruwa, Peradeniya
[2]Watawala Dairy Pvt Ltd., Hatton
* janakvid@pdn.ac.lk

Effect of *Azolla pinnata* on Growth and Nutrition of Rice (*Oryza sativa* L.) Under Reduced-Water, Nitrogen and Phosphorus Applications

Herath H.M.N.M., Ariyaratne M. and Suriyagoda L.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Nitrogen (N) and phosphorus (P) are considered essential for the growth of crops. Fertilizers applied to crops lost through different mechanisms causing environmental problems. *Azolla* has the potential to provide N supplement as it has significant biological N fixation, fast growth rate and high biomass production. Availability of water and P is essential for the growth of *Azolla*. However, water is a scarce resource. Therefore, this experiment was conducted to evaluate the effect of *Azolla* on growth and nutrition of rice grown under reduced-water, N and P applications. Rice variety Bg 300 was grown in pots and treated with 16 treatment combinations representing three factors; i.e. with and without *Azolla* application, continuous flooding and flooding and draining irrigation methods, and N+P+, N+P-, N-P+ and N-P- fertilizer treatments. Plant height has increased with *Azolla* application while it reduced leaf P and K. Reduced water has decreased leaf P and K and enhanced the N levels in *Azolla*. Irrigation methods did not affect on the growth parameters of rice. Nitrogen and P applications have significantly affected the growth and nutrition of both *Azolla* and rice. Without N and P fertilizers, growth and nutrition of rice were reduced. Plant height, flag leaf area, flag leaf greenness and shoot dry weight were increased with N and P applications. Rice leaf N, *Azolla* N and P have increased with the N+ treatments. Leaf P was increased with the P+ treatments. *Azolla* application was not successful without N and P fertilizer applications. Combined application of N, P and *Azolla* has shown a potential to increase the growth and nutrition of rice.

Keywords: *Azolla*, Biological nitrogen fixation, growth and nutrition

* lalith.suriyagoda@gmail.com

Effect of Pretreatment Methods and Packaging Materials on Colour Degradation of Chilli (*Capsicum annum* L.) Powder

Dulanjala S.D.H., Arampath P.C.* and Dimbulkumbura T.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Chilli (*Capsicum annum* L.) is one of the most consumable spice in the world. Colour degradation of chilli powder during the storage is a critical issue in the spice industry. The research was conducted to evaluate the effect of pretreatments, with and without removal of stalks attached to the dried chilli pods and cleaning of dried chilli pods with hot water (80-90°C/5min). Further, effect of four types of packaging materials (LDPE, (12mic.PET+12mic.PET+25mic.CPP), (12mic.PET+12mic. MET.PET + 40 mic.CPP) and (12 mic.PET+ 9 mic.Alfoil + 50 mic.CPP) on colour change of chilli powder was investigated. The samples of industrially processed chilli powder, manually processed chilli (variety MI Hot) powder were used for the experiments in pretreatments. All the chilli powder samples were stored in four different packaging materials and stored for 60 days of period under ambient condition. Ash content, moisture content, microbial tests (aerobic plate count, yeast and mould), and surface colour (L*, Chroma, hue angle) were conducted at 20 days interval. Initial moisture content of 10.11±0.41% reduced to 8.43±0.18% after 60 days. There was no significant difference ($P > 0.05$) in moisture content among the chilli samples. Yeast & mould count was below the Sri Lankan Standard (SLS 1563:2017) limit (maximum 10^3 CFU/g) during the storage period. There were no significant effects ($P > 0.05$) of pretreatments methods and packaging materials on microbial growth during 60 days of storage period. There was no significant ($P > 0.05$) effect on colour change in chilli powder cleaning with hot water (80-90°C /5min) and the type of packaging material used. Removal of stalks of the pods and microbial growth in chilli powder were significantly ($P < 0.05$) affected on colour change. In conclusion, surface colour of chilli powder was positively influenced by microbial contamination and growth during processing, packaging and the storage.

Keywords: Extractable colour, Microbial growth, Moisture content, Storage, MI hot

[1]Ruhunu Foods(Pvt) Ltd, Kandy Industrial Park(BOI),Pallekale, Kandy, Sri Lanka

* pcarampath@gmail.com

Effect of Roasting of Coriander Seeds on Total Phenolic Content and Anti-inflammatory and Free Radical Scavenging Activities of Aqueous Extracts

Herath H.N.M.N., Illeperuma D.C.K.*, Gunathilake K.D.P.[1] and Jayasinghe C.V.L.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Coriander (*Coriandrum sativum vulgare* Alef) seeds are roasted and used in traditional medicine to treat inflammatory diseases. Chronic inflammations leading to tissue damage can be minimized by supressing free radicals and secretion of inflammation markers from cells. Therefore, effect of roasting of coriander seeds at 120, 140 and 160 ^{o}C for 15 min on free radical scavenging activity, anti-inflammatory activity and total phenolic content of aqueous extracts was studied. Moisture contents, determined by distillation at 105±4 ^{o}C for 4 h in a Clevenger apparatus, of unroasted seeds and those roasted at 120, 140 and 160 ^{o}C were 6.52±0.6, 2.32±0.03, 1.53±0.06 and 1.23±0.06% respectively. Colour of unroasted and roasted coriander seeds was analyzed using a Chromameter and expressed as L*, a* and b* values. The lowest L* value of 30.73±0.58 and the highest a* and b* values of 17.9±0.2 and 29.75±0.42 respectively, were evident in seeds roasted at 160 ^{o}C. Unroasted and roasted seeds were powdered by grinding and sieving through a mesh of 0.425 mm pore size. Decoctions were prepared by heating powdered samples at 60±5 ^{o}C in clay pots for 150 min while maintaining a solid to water ratio of 6:100 (g/mL). The highest DPPH radical scavenging activity (87.48±2.35% inhibition) of decoctions of seeds roasted at 140 ^{o}C and the highest anti-inflammatory activity (58.1±0.41% inhibition) of decoctions of unroasted seeds were evident. Total phenolic contents of decoctions of unroasted and those roasted at 140 and 160 ^{o}C were not significantly different ($p>0.05$). Considering the highest DPPH radical scavenging activity, roasting of coriander seeds at 140 ^{o}C for 15 min could be recommended for preparing decoctions or any other application.

Keywords: Coriander, Inflammation, Free radical scavenging activity, Roasting

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[1]Department of Food Science and Technology, Faculty of Livestock, Fisheries and Nutrition, Wayamba University, Makandura, Gonawilla

* dchamaraki@hotmail.com

Effect of Seasonal Variation on Dietary Fiber Content and Physical Properties of Some Selected Traditional and Improved Rice Varieties in Sri Lanka

Herath H.M.K.W.P., Prasantha B.D.R.* and Rebeira S.P.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Traditional and improved rice varieties (*Oryza sativa* L.) grow in *Yala* and *Maha* seasons under all agro-ecological zones due to their wide climatic adaptation. In this study, three traditional rice varieties (*Pachchaperumal*, *Suduheenati and Suwandel*) and three improved rice varieties (BG 360, BG 358 and BW272-6B) were cultivated in 2016 and 2017 *Yala* and *Maha* seasons. Harvest and milled rice samples were analyzed to determine the effect of seasonal effects of physical and dietary fiber content. Gelatinization temperature (^{o}C), grain hardness (N), minimum cooking time (min), elongation ratio, solid loss (%), swelling power (g/g), volume expansion ratio and soluble, insoluble and total dietary fiber content (g/100g) of the rice samples were determined. There was no significant variation ($p>0.05$) of gelatinization temperature, grain hardness, minimum cooking time, solid loss percentage, elongation ratio and swelling power between the cultivation season. However, rice samples harvested in *Maha* season showed significantly higher ($p<0.05$) volume expansion ratio (4.58±0.19) compared to the rice harvested from *Yala* season (3.55±0.35). Both red and white pericarp color rice varieties showed similar values for the volume expansion ratio, solid loss percentage, elongation ratio and swelling power. However, red rice varieties showed significantly higher ($p<0.05$) minimum cooking time (33.75±0.03 min) compared to that of white rice varieties(24.14±0.02 min). Grain hardness was high in red rice varieties (50.00±0.19 N) compared to the white rice varieties(39.04±0.21 N). Traditional rice varieties showed longer minimum cooking time (33.92±0.10 min) than improved rice varieties(23.97±0.08 min). Traditional rice varieties showed significantly higher ($p<0.05$) solid loss (5.55±0.34%), grain hardness (49.03±0.01 N) and swelling power (11.41±0.24) than improved rice varieties. Soluble dietary fiber, insoluble dietary fiber or total dietary fiber content did not show a significant variation ($p>0.05$) between the *Yala* and *Maha* seasons.

Keywords: Rice, *Yala*, *Maha*, Cooking, Dietary fiber

[1]Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya

* rop_bd@yahoo.com

Effect of Water activity, Storage Temperature, Particle size and Type of Packaging material for color stability of chilli powder

Chathuranga M.D.D., Wadasinghe A.[1], Prasantha B.D.R.[*] and Chandrasiri K.A.K.L.[2]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Color deterioration of chilli powder during shelf-life is a critical problem. Investigation about the factors affected color deterioration was of great importance. The aim of this study was to identify the effect of different factors such as water activity (a_w), storage temperatures, particle size and type of packaging material on the color stability of chili powder. The effect of different a_w levels established at two different temperature for change in L*, a* and b* coordinates was tested. Effects of four different particle size ranges (500-250 µm) and two types of packaging material (PET/CPP and PET/PET/CPP) for total color difference (TCD) were evaluated during storage. At both temperatures tested, L*, a* and b* values showed a negative relationship with a_w. A significantly higher ($p<0.05$) change in TCD was observed at higher storage temperature and smaller particle size range. Out of the two package materials used, TCD of chilli powder in triple laminate was significantly higher ($p<0.05$) than double laminate packaging material.

Keywords: Chili powder, water activity, storage temperature, particle size, packaging material

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[1]Nature Industries & Distributors (Pvt.) Ltd.

[2]Department of Food Science & Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya

* rop_bd@yahoo.com

Effect of Waxing of Clay Pots on Shrinkage and Mold Growth of Buffalo Curd

Subasinghe S.A.R.M., Prasanna P.H.P.* and Gunasekara D.C.S.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The aim of this study was to evaluate effect of application of different waxes on clay pots on shrinkage and mold growth of buffalo curd. There were 5 treatments; control (clay pots without wax coat), clay pots of which the interior surface was fully coated with bee wax, clay pots of which the round interior surface was coated with bee wax, clay pots of which the interior surface was fully coated with paraffin wax and clay pots of which the round interior surface was coated with paraffin wax. The sample curd pots were kept in refrigerated storage. Shrinkage, weight loss, syneresis, pH and microbial properties of buffalo curd were determined up to 19th day of storage period. The experiment was according to Complete Randomized Design (CRD). Data were analyzed using one-way ANOVA and Friedman test. The results showed that the clay pots of which the interior surface was fully coated with paraffin wax reduced mold growth and improved sensory attributes of buffalo curd compared to other treatments. Higher shrinkage reduction of buffalo curd was observed in clay pots of which the interior surface was fully coated with bee wax compared to other treatments. Clay pots of which the interior surface was fully coated with paraffin wax could prevent the mold growth of buffalo curd up to 19th day. This study showed that application of paraffin wax on the interior surface of clay pots could significantly ($P<0.05$) reduce shrinkage and mold growth of buffalo curd.

Keywords: Bee wax, Paraffin wax, Sensory attributes

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[1]CIC Dairies (Pvt) Ltd., Ibbankatuwa, Dambulla

* phpprasanna@agri.pdn.ac.lk

Efficiency of Modified Atmosphere Treatments for Pest Control and Preservation of Quality Characteristics of Dehydrated Jackfruits

Rifath M.R.A., Prasantha B.D.R.*, Chandrasiri K.A.K.L. and Yatiwala S.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The modified atmosphere packaging is used as an alternative technique for the chemical preservation of food products. This study investigated the efficiency of modified atmosphere (MA) treatments either with carbon dioxide (CO_2) or nitrogen (N_2) gases for the pest control and quality preservation of dehydrated jackfruit. The mortality of Indian meal moth (*Plodia interpunctella*) larvae and adult rice weevil (*Sitophilus oryzae* L.) artificiality infested dehydrated jackfruit samples were exposed to N_2 ((99%) or CO_2 (99%) treatments. The mortality rate of Indian meal moth larvae and adult rice weevil was higher in CO_2 gas treated samples than N_2 treated samples. Color, moisture content, pH, Brix value, titratable acidity, and microbial quality of the modified atmosphere treated dehydrated jack fruits were also investigated. The color of the dehydrated jackfruit samples did not show any significant difference ($p>0.05$) before and 60 days after CO_2 treatment. Brix value and microbial counts have shown significant differences ($p<0.05$) during the 60 days of storage.

Keywords: Modified atmosphere, *Sitophilus oryzae* L., *Plodia interpunctella*, Dehydrated jack fruit, Quality

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[1]HJS Condiments Limited, Biyagama

* rop_bd@yahoo.com

Evaluating Six Types of Rice Packaging Materials for the Vulnerability of Damage Caused by Adult or Immature Stage of Maize Weevils, *Sitophilus zeamais*, Confused Flour Beetles, *Tribolium confusum* and Rice Moth, *Corcyra cephalonica*

Rajarathna R.M.B.G.B.M., Hemachandra K.S.* and Mahroof R. M.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rice, *Oryza sativa* L. (Poaceae) is the staple diet in Sri Lanka. Rice is available for the customers in different quantities packed indifferent packaging materials. Maize weevil (*Sitophilus zeamais*) (Coleoptera: Curculionidae), confused flour beetle (*Tribolium confusum*) (Coleoptera: Tenibrionidae) and rice moth (*Corcyra cephalonica*) (Lepidoptera: Pyralidae) are important pests in stored raw and processed rice. Packing materials are the barriers for infestation of these pests. This study was conducted with the objective of evaluating 6 types of rice packaging materials against insect infestation. Packing materials were evaluated for its vulnerability for penetration or invasion of selected pests when processed rice is stored. Adults or immature stages of above insects were introduced to 6 plastic boxes that contained rice packed with one of the six packaging materials. Gunny sacks, polyethylene (gauge 250), polypropylene (gauge 250), polysack, polysack layered with polyethylene, paper and cloth materials were tested as packaging materials. Resistance for penetration of maize weevil was significantly different (χ^2 =92.4 df=6 P<0.05) among materials. Gunny sack (96%) and polysack (88%) were susceptible while other materials were 100% resistance for penetration. That of for confused flour beetle was also significant (χ^2=87.2 df=6 P<0.05) and gunnysack (94%) and polysack (90%) were susceptible while other materials were 100% resistance for penetration. A similar trend was observed for *Corcyra* larvae. Resistance for penetration was significantly different (χ^2=71.1 df=6 P<0.05) among materials and gunnysack (74%) and polysack (68%) were susceptible while other materials were 100% resistant for penetration. As per the data, the materials: polyethylene (gauge 250), polypropylene (gauge 250), polysack layered with polyethylene, paper and cloths are recommended to use as packing materials for raw rice to minimize the rice pest infestation after packing.

Keywords: *Corcyra cephalonica*, *Oryza sativa*, *Sitophilus zeamais*, Sri Lanka, *Tribolium confusum*

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[1]Department of Biological and Physical Sciences, South Carolina State University, USA

* kshema@pdn.ac.lk

Evaluation of Physicochemical and Technological Properties of Pumpkin (*Cucurbita maxima*) Flesh, Peel, Seed and Mixed Flour

Prathibani I.G.O.N., Wijesinghe D.G.N.G.* and Jayawardana S.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was designed to produce pumpkin (*Cucubita maxima*) flesh, peel, seed and mixed flour and to determine their physicochemical and technological properties. The ash, moisture, pH, colour, and dietary fiber were the physicochemical properties while the solubility and absorption were the technological properties studied. The yields after drying and milling were also measured in each flour type. The results were analysed using Tukey-Kramer test in SAS version 9.0. According to the results, the highest and the lowest yield in pumpkin were obtained by the seed flour (67.0%) and flesh flour (10.1%), respectively. There was no significant difference of the ash contents among flour types and the values ranged between 5.55% and 5.57%. The colour of the mixed and flesh was not significantly different but peel and seed flour showed a significant difference ($p<0.05$). Dietary fibre showed significant differences ($p<0.05$) among flour types and the highest fibre was in the seed flour (43.1 g/100g). The pH values ranged from 5.85 to 6.66 and showed a significant difference ($p<0.05$) among flour types. The technological properties were analyzed for pumpkin-based flour fractions and compared with all-purpose wheat flour. The highest water absorption was observed in pumpkin flesh flour (6.61 g.gel/ g of dry matter) while the highest water solubility was in the mixed flour (47.2%). Milk absorption of all the pumpkin-based flour types showed lower values than that of wheat flour (4.3 g.gel/g of dry matter) but the highest milk solubility (3.1%) and the highest oil absorption (5.17 g.gel/g of dry matter) were observed in pumpkin flesh flour. The oil absorption between the peel flour and mixed flour was not different. In conclusion, the pumpkin based flour types can be added to various food systems to improve functional properties and the nutrient content.

Keywords: *Cucubita maxima*, Physicochemical properties, Technological properties

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[1]Food Technology Section, Industrial Technology Institute, Malabe

* wijeng@yahoo.com

Indigenous Herbal Shampoo/Lotion for Skin Infections

Weerasinghe D.S.D., Jinadasa H.R.N.[1] **and Wijayagunawardane M.P.B.***
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The effectiveness of an indigenous herbal shampoo and a lotion prepared for controlling skin infections was investigated. Herbal shampoo and lotion were manufactured using indigenous recipes containing antibacterial, antifungal, and antiparastic properties. Antibacterial properties of herbal shampoo were tested against the Gram positive (*Staphylococcus aureus)* and Gram negative (*Pseudomonas aeruginosa*), which are the most common species causing bacterial skin infections. The antibacterial effect was investigated using different concentrations of the products (25, 50, 100, 200 µL/mL) on Muller Hinton Agar by well diffusion method. Growth media was incubated under 37°C for 24 hours. Minimum Inhibitory Concentration (MIC) and Minimum Bacterial Concentration (MBC) were identified using a two-fold nutrient broth dilution method at concentrations ranging from 0.097 to 50µL/mL. Moreover, a clinical trial was conducted using 15 dogs with skin infections. According to the results, indigenous herbal shampoo and lotion were more effective against the Gram positive bacteria than Gram negative bacteria at a concentration of 25 µL/mL or more. Clinical trial showed a considerable improvement of dog's skin condition within 2 weeks. The result of the study indicates that the prepared herbal shampoo/lotion is effective to control skin infections. Thus, it has the potential to commercialize the preparation.

Keywords: Indigenous herbs, Shampoo, Skin infection control

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[1]Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science. University of Peradeniya, Peradeniya

* missakaw@pdn.ac.lk

Isolation, Identification and Characterization of Potential Probiotic Bacteria from Cow Colostrum from Sri Lankan Dairy Cattle Farms

Rajapaksha R.M.S.P., Vidanarachchi J.K.*, Kodithuwakku S.P., Prasanna P.H.P. and Jayathilake J.A.M.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The current study was conducted with the aim of identifying lactobacilli species present in cow colostrum collected from Sri Lankan dairy cattle farms as a sources of probiotics. Cow colostrum samples were collected into sterilized sampling bottles from 10 different selected dairy cattle farms. Lactobacilli species were identified from the isolates of colostrum samples and their identity was confirmed by appropriate morphological, biochemical and physiological tests. Probiotic properties of isolates were evaluated through bile tolerance, acid tolerance and antibiotic sensitivity tests. It was found that 43% of total isolates were lactobacilli isolates. Further, 93% of the lactobacilli isolates vigorously grow at 45°C and 47.5% of the lactobacilli isolates tolerate NaCl up to 6.5% (w/v). While all the lactobacilli isolates shown acid (pH=3.00 for 3 hours) and bile (0.3% for 4 hours) tolerance, none of them shown resistance to amoxicillin, chloramphenicol, gentamicin, tetracycline and erythromycin. It can be concluded that the lactobacilli isolated from cow colostrum from Sri Lankan dairy cattle farms are good source of probiotic bacteria. Further studies should be carried out to identify the health benefits of lactobacilli bacteria present in colostrum of Sri Lankan dairy cow herds.

Keywords: Probiotics, Cow colostrum, Lactobacilli

[1]Division of Microbiology, Department of Oral Medicine and Periodontology, Faculty of Dental Sciences, University of Peradeniya, Peradeniya

* janakvid@pdn.ac.lk

Method Validation for Quantification of Selected Non Nutritional Sweeteners and Preservatives and Caffeine in Carbonated Beverages Commercially Available in Sri Lanka

Jayasooriya J.A.G.K., Madhujith T.* and Guruge K.P.G.K.T.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

A study was carried out on validating a method for quantification of selected non-nutritional sweeteners, preservatives and caffeine in carbonated beverages commercially available in Sri Lanka. A liquid chromatography method with photo diode array detection was developed. Validation was performed in terms of linearity, specificity, reproducibility, recovery, Limit of detection (LOD) and Limit of quantification (LOQ) values. Aspartame, acesulfame-K and sodium saccharin were selected as non-nutritional sweeteners while benzoic acid and sorbic acid were selected as preservatives. Aspartame, acesulfame-K, sodium saccharin, benzoic acid, sorbic acid and caffeine showed linearity within 1-100 ppm range. Correlation coefficient (R^2) for all the compounds tested was higher than 0.996. Recovery of all the compounds ranged between 70% and 120%. The LOD values ranged between 0.054 and 0.097 ppm while the LOQ values ranged between 0.18 and 0.32 ppm. The Relative stand deviations were ≤ 5% for all the compounds. Extraction process was optimized using surface response methodology and box bhenken design. Process optimization was carried out by Design Expert Software Version 12.0. The optimum extraction conditions were found to be ultrasonic temperature 25 °C, time 10 minutes and mobile phase 50% (V/V) potassium dihydrogen phosphate/acetonitrile. Satisfactory separation and quantification could be obtained within 15minutes of total run time.

Keywords: Aspartame, Acesulfame-K and Sodium saccharin, Benzoic acid and Sorbic acid, Caffeine, Carbonated beverages

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[1]Government Analyst's Department, Battaramulla

* tmadhujith@agri.pdn.ac.lk

Physicochemical, Microbiological and Sensory Properties of Probiotic Drinking Yoghurt Incorporated with Guava Fruit Pulp

Dissanayaka N.S., Prasanna P.H.P.* and Gunasekara D.C.S.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was conducted to develop guava (*Psidium guajava)* fruit pulp incorporated drinking yoghurt through investigation of the optimum concentration of natural guava fruit pulp which can be added into standard drinking yoghurt. A preliminary study was conducted to determine the best way of incorporation of fruit pulp and the effective time to incorporate fruit pulp into the drinking yoghurt. Guava fruit pulp was prepared without peel and fruit pulp was incorporated into the mixture after the inoculation. The final products were stored at 4ºC for 28 days, and physicochemical properties, rheological properties and microbiological properties such as viability of probiotic bacteria, yeast and mould and coliform were evaluated weekly during storage. Sensory evaluation of the study revealed that treatment containing 3% (v/v) guava fruit pulp had higher sensory scores than other treatments. The pH of 3% (v/v) guava fruit pulp incorporated drinking yoghurt changed from 4.54 to 4.29 during the storage period, while titratable acidity increased from 0.57% to 0.80%. Syneresis and water holding capacity significantly increased during the storage. Coliform was not detected in all levels of guava fruit pulp, while yeast and mould count of yoghurt drink were within the acceptable rage (1×10^3 CFU/ml) during the storage period. During the storage, *Lactobacillus acidophilus* LA-5, *Streptococcus thermophiles* and *Lactobacillus delbrueckii* spp. *bulgaricus* were alive in all treatments. Therefore, these results proved that guava fruit pulp could be successfully utilized to manufacture probiotic drinking yoghurt which can enhance physicochemical, microbiological and sensory properties.

Keywords: Drinking yoghurt, Coliform, Storage, Syneresis

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[1]CIC Dairies (Pvt) Ltd., Ibbankatuwa, Dambulla

* phpprasanna@agri.pdn.ac.lk

Potential of Using Cassava (*Manihot esculenta* L.), Sweet Potato (*Ipomoea batatas* L.) and Tannia (*Xanthosoma sagittifolium* L.) Flour in Developing Noodles

Milhana M.S.F., Rebeira S.P.[1] **and Jayanath N.Y.**[*]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was aimed to investigate the potential of using cassava, tannia and sweet potato flour (CF, TF and SPF respectively) to develop noodle and to formulate them into an optimum ratio aiming expected physico-chemical properties. Flours from tubers were obtained. Composite flour blends (CFB) were made by substituting wheat flour with one of the above flour at the levels of 40%, 60% and 80% and noodles were made from each CFB. All flour types and noodles were analyzed for swelling index (SI), solubility and water absorption capacity (WAC). Flours were analyzed for gelling temperature (GT) and noodles were analyzed for oil absorption capacity (OAC) and cooking properties such as cooking time (CT), cooking weight gain (CWG) and cooking loss (CL). Tannia flour showed a significantly ($p<0.05$) higher SI and GT while both TF and SPF showed a significantly ($p<0.05$) higher WAC. Solubility was significantly ($p<0.05$) lower for CF and TF. There was no significant difference ($p>0.05$) among GT, solubility and SI of SPF and control. A similar observation was done for GT and WAC of CF and control. All composite flour noodles showed a significantly ($p<0.05$) lower WAC and SI and significantly ($p<0.05$) higher CT and OAC compared to the control. All the noodles of CFB except SPF had a significantly ($p<0.05$) lower solubility and CL compared to the control. Cooking weight gain of CF and SPF noodles was similar to the control. Sweet potato flour and TF substitutions had no significant effect ($p>0.05$) on OAC and CWG respectively. Noodles made out of CF CFB showed a significantly ($p<0.05$) better OAC, SI, and cooking properties compared to the control. Noodles made out of CFB at 80% substitution was significantly preferred compared to other levels, for all the flour types. Noodle with CFB containing 80% of CF was more acceptable.

Keywords: Cassava, Composite flour, Cooking properties, Sweet potato, Tannia

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[1]Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya

* jayanath11@gmail.com

Preservation and Bulk Storage of Lime (*Citrus aurantifolia)* and Determination of its Shelf Life

Buddika W.A.K.K.S., Arampath P.C.* and Samita S.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The preliminary research has been conducted on a laboratory scale and the main objective was to scale up the laboratory protocol to an industrial scale. The main emphasis was given to develop a methodology to preserve and bulk storage of lime at the ambient condition with low-cost inputs that is suitable for small and medium scale industries. Coir dust was used as the medium with four treatments; medium only, coarse charcoal powder (5 g/100 g medium), Potassium permanganate ($KMnO_4$ 5 g/100 g medium), a mixture of charcoal (5 g and $KMnO_4$ 5 g /100 g medium). Sand was used as the medium with one treatment, medium only. The samples were stored in HDPE bags (black color, 300 gage), in the treated media (1 kg fruit/3 kg sand and 1 kg fruit/500 g coir dust) at ambient temperature (26±2 ^{o} C). The control was stored under the ambient condition. The skin color of fruits, pH, titratable acidity, Total Soluble Solids (TSS) and vitamin C of lime juice were measured weekly for 1 month. Sensory evaluation (9 points Hedonic scale) was conducted after one month for the lime juice extracted from stored fruits. Based on skin color, lime fruits stored in coir dust with 5 g/$KMnO_4$ treatment was the best treatment to preserve green color after 4 weeks. Titratable acidity of fresh lime juice and juice from preserved fruits (after 4 weeks) was 7.42 and 6.63 (10.7% difference) respectively. Therefore, $KMnO_4$ 5 g/100 g coir dust was recommended as the best treatment for bulk storage of fresh lime fruits at ambient temperature (26±2 ^{o}C) for industrial and culinary uses even after the 4 weeks. The coir dust was the least effective treatment and the de-greening of skin color appeared in the 3rd week of storage.

Keywords: Lime fruit, Shelf-life, Storage media, Charcoal, $KMnO_4$

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[1]Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
* pcarampath@gmail.com

Production of 'Madan' (*Syzygium cumini*) Wine and Study of the Quality Parameters with Storage Time

Nishadini H.A.V., Dharmasena D.A.N.* and Madhujith W.M.T.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Red wine is usually produced from grapes (*Vitis vinifera*) but there are no commercial vineyards in Sri Lanka. Madan (*Syzygium cumini*) is an underutilized natural fruit in Sri Lanka and it can be an alternative due to its peculiar color. Therefore, this study was conducted to compare the quality parameters and bioactive agents in Madan and grape wines during storage. Washed Madan fruits were disinfected and hand crushed to produce must by adding one liter of water per one kilogram of fruits. Then the final alcohol percentage was adjusted to 14% using a wine specific gravity tester by adding sugar. Starter culture was added to the must and allowed to ferment for 9 days. Wine was siphoned, bottled and kept in an incubator at 2 ^{0}C for racking. Grape wine was prepared and stored in the way. Antioxidant activity, antioxidant power, Total Monomeric Anthocyanin Content (TMAC), Total Soluble Solids (TSS) and color of wine were measured during the racking period in two-week intervals for 15 weeks. DPPH radical-scavenging assay, Ferric Reducing Antioxidant Power (FRAP) assay and pH differential method were used to measure the antioxidant activity, antioxidant power and TMAC, respectively. Finally, a sensory evaluation was conducted to investigate the consumer acceptance of Madan wine, grape wine and a commercial red wine. Higher antioxidant activity, antioxidant power, TMAC, TSS, redness (a*) coupled with a lower lightness value were found in Madan wine than grape wine. The sensory acceptance of Madan wine was better in terms of color, aroma, flavor and overall acceptability than grape wine. It was revealed that there was no significant difference between the flavor of Madan wine against the commercial red wine ($P<0.05$). Therefore, Madan has a great potential for making red wine having additional health benefits to the wine consumer.

Keywords: Red wine, Madan, health benefits, antioxidant activity, total monomeric anthocyanin

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[1]Department of Food Science & Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya

* nimal.dharmasena@gmail.com

Quantification of ɤ-Oryzanol in Selected Sri Lankan Traditional Rice Varieties and the Effect of Cooking on ɤ-Oryzanol Content

Saruthya I.C., Somasiri H.P.P.S.[1] **and Madhujith T.***
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rice is the staple food for more than half of the world. Rice production as well as consumption have been on the rise year by year keeping abreast of rising population. Traditional rice varieties have been gaining attention for the presence of bioactive compounds. Consumer attitude towards healthy food is promising the scope for the increase in demand for traditional rice varieties and brown rice consumption. ɤ-Oryzanol which is a mixture of ferulates and esters, is an important bioactive compound of rice bran. This study was carried out to investigate the ɤ-oryzanol content of selected Sri Lankan traditional rice varieties and the impact of cooking on ɤ-oryzanol content of rice. Samples were obtained from Rice Research and Development Institute, Bathalagoda and Department of Agriculture, Thinnaveli. Particle size reduction to 355 µm and acid hydrolysis were done to facilitate oil extraction from both raw and cooked rice. Hexane was used to extract oil from rice. Reverse phase high performance liquid chromatography with UV detection (330 nm wavelength) was used for the quantification of ɤ-oryzanol from the extracted oil. ɤ-Oryzanol content of raw rice samples ranged from 27.71 to 540.75 µg/g of rice and the corresponding values for cooked rice samples were 15.84 to 17.47 µg/g. Varieties *Kaluheenati, Behethheenati, Madathawalu, Murungakayan, Sulai* and *Periyavellai* exhibited comparatively high quantity of ɤ-oryzanol. Cooking showed a drastic reduction of ɤ-oryzanol content from 87.08% to 92.56% in rice varieties tested.

Keywords: Cooking, High performance liquid chromatography, Oil extract, ɤ-Oryzanol, Traditional rice

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[1]Industrial Technology Institute, Colombo 07

* tmadhujith@agri.pdn.ac.lk

Stability of Oil-in-Water Emulsions Performed by Ultrasonication and Homogenization

Jayani P.S., Gunawardana M.[1] **and Rajapakse R.P.N.P.***
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Emulsion systems are widely used in many applications including functional foods, drug delivery, pharmaceuticals, and nutritional supplements, *etc.* High-pressure homogenization is a conventional method of preparing emulsions and ultrasonication is a novel approach to prepare emulsions with high efficiency. Coconut oil has attracted great attention in developing emulsions for many applications. However, the stability of coconut oil-based emulsions prepared using the above methods have not been studied previously. Therefore, this study was aimed to find the impact of ultrasonication and homogenization on the stability of coconut oil-based emulsions. Accordingly, the best ultrasonication time was selected with the frequency of 20 kHz using oil to water ratio of 20:80% (w/w). Three different emulsifiers namely poly-ethylene glycol (PEG) 4000, tween 20, and tween 80 were used with different concentrations to select the best concentration in preparing 20% (w/w) coconut oil emulsion. Thereafter, homogenization and ultrasonication treatments were performed separately to select the best formulation for each emulsifier. The droplet diameter, the height of the oil layer, viscosity, pH, microstructure view, and phase separation were measured over the storage period. According to the observations, 15 min was selected as the best time for the ultrasonication and 10% (w/w) PEG 4000, 1.5% (w/w) tween 20 and 2.5% (w/w) tween 80 were identified as the best emulsifying conditions separately for 20% (w/w) coconut oil, oil-in-water emulsions. Ultrasonication resulted the lowest droplet diameter and clear microscopic structure in the emulsions compared to that in emulsions prepared using homogenization. After 14 weeks of storage time, homogenized samples resulted a clear phase separation than that in the ultrasonicated samples. The findings of this study clearly confirm that ultrasonication yields stable oil-in-water emulsions of coconut oil compared to homogenization with suitable emulsifiers.

Keywords: Emulsion, Ultrasonication, Homogenization, Oil-in-water emulsion

[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama
* n_rajapakse@yahoo.com

Study on Physico-chemical Properties of *Mee (Madhuca longifolia)* Oil and the Effect of Repeated Heating on the Chemical Composition and Quality

Pushpakumara A.G.S.K., Somasiri H.P.P.S.[1] and Madhujith T.*
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Mee (*Madhuca longifolia),* a locally available plant that has been used as a source of edible frying and cooking oil in Sri Lanka long ago. However, *Mee* plant is nearly extinct and oil extracted from *Mee* is used only in Ayurvedic medicine. The aim of this study was to determine the physico-chemical properties of *mee* oil with special emphasis on fatty acid composition and to evaluate its applicability as a frying oil. The physico-chemical properties were analysed using standard methods while fatty acid profile was determined using gas liquid chromatography. Oil was heated at 120 °C and 150 °C with 3 cycles per each temperature for 20 min and the changes in colour, refractive index, acid value, peroxide value and the *trans* fat content were assessed. The crude fat content was found to be 51±0.5%. Colour of oil was Y=20, R=2.8, slip melting point was 31.7±0.4 °C, smoke point was 155±7 °C, refractive index was 0.9052±0.01 at 27 °C, specific gravity was 1.4617±0.01 at 32 °C, saponification value was 200±5.75 mg KOH/g, iodine value was 56±0.13 g I_2/100 g, acid value was 4.9±0.22 mg KOH/g and peroxide value was 8.48±0.39 meq/kg. The major fatty acids in *Mee* oil were oleic (47.58±0.08%), stearic (20.54±0.09%) palmitic (19.83±0.12%) and linoleic (10.79±0.03%). It was further revealed that the saturated, monounsaturated and polyunsaturated fatty acid contents were 41.15, 47.62 and 11.23%, respectively. *Mee* oil did not contain any detectable levels of *trans* fat. It was revealed that the degradation of oil during heating starts at fairly lower temperature of 150 °C thus *Mee* oil might be beneficial to use in raw form or in mild heat processes.

Keywords: *Madhuca longifolia*, Seed oil, Fatty acid profile, Repeated heating

[1]Industrial Technology Institute, Colombo 07

* tmadhujith@agri.pdn.ac.lk

Study on Quality and the *Trans* Fat Content of Shortenings and Fat Spreads Used for Manufacturing Bakery Products in Sri Lanka

Herath H.M.N.A., Weerasinghe W.M.P.B.[1] **and Madhujith T.***
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was aimed at determining physico-chemical properties, fatty acid profile with emphasis on *trans* fatty acids (TFA) and assessing the oxidative stability of shortenings and fat spreads used for manufacturing bakery products in Sri Lanka. Nine brands of shortenings and fat spreads were collected from 4 districts namely Colombo, Kandy, Galle and Anuradhapura. The Acid Value (AV), Saponification Value (SV), total fat content, moisture content and colour were determined using standard methods while melting profile was determined as Solid Fat Content (SFC). The oxidative stability was evaluated by Peroxide Value (PV), *p*-Anisidine Value (*p*-AV), Totox value and Thiobarbituric Acid Reactive Substances (TBARS) value. The fatty acid composition was determined by Gas Liquid Chromatography (GLC). Among the tested shortenings and fat spreads, product A exhibited the highest AV (0.56 ± 0.03 mg KOH/g fat) which was not in accordance with the requirements of the Sri Lankan Standards (SLS) 1427:2011. SV ranged from 96.24 ± 1.49 to 220.44 ± 1.06 mg KOH/g fat. Only 2 products of 4 brands of margarine were in conformity with CODEX 256-2007 pertaining to the fat content while 5 products were in compliance with the requirements for fat spreads. All products exhibited less than 10% of moisture. It was revealed that product D was the most stable while product A was the least stable in terms of their vulnerability to oxidation. According to the GLC analysis, saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acid contents were present at 13.1-52.1%, 0.5-31.8% and 0.7-31.6% of total fatty acids, respectively. High levels of SFA indicated a significant contribution of palm and coconut oils in the manufacture of shortenings and fat spreads. The low TFA content (0.3-2.1% of total fatty acids) has led to an increase in fat saturation which is an alarming health issue.

Keywords: Fatty acid profile, Gas liquid chromatography, Physico-chemical properties, Shortenings, *Trans* fatty acids

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[1]Division of Pasture and Fodder Crops, Veterinary Research Institute, Gannoruwa, Peradeniya

* tmadhujith@agri.pdn.ac.lk

The Effect of Osmotic Pre-Treatment and Freezing Method on the Quality of Frozen Mango (*Mangifera Indica* L.) and Pineapple(*Ananas Comosus* L.) Slices

Hasna S.H.F., Senarathne S.M.A.C.U.[1] and Rajapakse R.P.N.P.*
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was aimed to evaluate the combined effects of osmotic dehydration (OD) with or without addition of calcium chloride as a pretreatment, and freezing method on the quality of frozen mango and pineapple slices. Ice crystal formation during freezing causes severe textural damage in frozen fruits. In this study, mature and unripen fruits were selected to improve cryoprotection during freezing. Osmotic dehydration was carried out (2 h at 30 ^{o}C), using sucrose solutions (30 or 50 ^{o}Brix), with or without added calcium chloride (0.25% (w/w)), with a fruit to solution ratio of 1:5 (w/w). Osmotically dehydrated fruits were frozen either by conventional freezing (at -18 ^{o}C) or by airblast freezing (at -35 ^{o}C, 3 ms^{-1} air velocity). Osmodehydro-frozen samples were then thawed and analysed for drip loss, total soluble solids (TSS), pH, titratable acidity (TA), vitamin C content, firmness and color. Calcium chloride pretreatment followed by airblast freezing significantly ($p<0.05$) favoured retention of acidity, reduction of drip loss, maintenance of firmness and preservation of the natural color. Osmotic dehydration carried out with a higher concentration of sucrose and added calcium chloride significantly ($p<0.05$) increased TSS content and maintained firmness while preserving the natural color. However, OD significantly ($p<0.05$) increased drip loss and reduced TA and vitamin C content. Freezing method and calcium chloride pretreatment had no significant ($p>0.05$) effect on vitamin C content. The results of this study reveal that, airblast freezing of osmotically dehydrated mango and pineapple slices pretreated with calcium chloride develops a higher acceptance compared conventional freezing due to preservation of important physicochemical properties.

Keywords: Airblast freezing, Drip loss, Firmness, Osmotic dehydration, Total soluble solids

This research was funded by AFACI project, Department of Agriculture, Food Research Unit, Gannoruwa

[1]Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya

* n_rajapakse@yahoo.com

Thermo-Chemical Extraction of Bio-Oil from Poultry Feather Waste

Rumaiz H.M.M., Silva G.L.L.P.* and Karunarathna A.K.[1]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Research on feathers pyrolysis is important to find out their potential utilization. The present study was focused on developing an efficient process to produce a high amount of bio-oil from poultry feather waste. The sample consisted of chicken feathers obtained from commercial scale broiler processing plant. A specially designed pyrolysis reactor consisted of a thermo-hydral pyrolyser and a heating chamber was used. The experimental temperature range was 500-650 ^{o}C. The results revealed that minimum treatment period for complete volatile fraction release varied between 4-12 min. depending on process temperature and heating rate (~120 ^{o}C). The bio-oil mass fraction represented 56% to 66.7% of the pyrolysis products. The minimum char fraction was generated at 550-600 ^{o}C and yield was 8.3%. The gas yield was sharply increased with increasing temperature from 450 ^{o} C to 650 ^{o}C. The lowest gas yield of 20.8% was observed at 450-500^{o}C and the highest gas yield of 28% at 600-650 ^{o}C.Thus, results confirmed that low temperatures (<550^{o}C) increased the char formation and high temperatures (>600 ^{o} C) increased the gas formation. Medium temperature fast pyrolysis at a heating rate of 127.5 ^{o}C/min for 12 min. maintaining the temperature at 550-600 ^{o}C, which yielded a high amount ofbio-oil (67%), low amount of char (16%) and the medium amount of gas products (17%), was considered as the efficient process conditions for poultry feather pyrolysis. Further experiments are needed to study the composition of pyrolysis products.

Keywords: Bio-oil, Char, Pyrolysis, Thermo-chemical

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[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya

* pradeepas@pdn.ac.lk

Uniformity of Iron Distribution in Fortified Blended Rice after Cooking

Sriskumar S., Dharmasena D.A.N.*, Silva F.H.C.A. and Gunawardane C.R.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

About one-third of Sri Lankans suffer from iron deficiency and this is the most widespread micronutrient deficiency in Sri Lankan population at present. Rice is the staple food and it is a good vehicle for iron-fortification. The challenge is to provide the micronutrient uniformity before and after cooking to assure uniform iron intake for the target population while reducing possible negative effects due to high doses. The present paper evaluates the uniformity of iron content in different rice types before and after cooking. The blending ratio of fortified kernel to normal rice was 1:99 (1%) and with the coefficient of variability (CV) of blending below 15%. Blended rice samples were cooked in a rice cooker and divided into sixteen portions based on the location of the cooked rice mass, which were considered as treatments. A coloring test was used to visualize the distribution of kernels after cooking and iron content analysis was done by an Atomic Absorption Spectrophotometer (AAS). Kernel detection tests revealed that the iron distribution at the periphery of the rice bowl was higher than the center locations. Further, the statistical analysis confirmed that there is a significant increase ($p<0.05$), of iron content at the periphery than center locations for all selected blended rice samples after cooking. The kernel motion in a systematic pattern inside the cooking pan during cooking is due to the differences of physical characteristics such as specific gravity, shape, length, width, etc. between normal rice and the kernel. Those differences transport the kernel along with the convectional currents of water created inside the bowl due to temperature difference. Therefore, it is recommended to mix cooked rice thoroughly to assure uniform iron distribution among consumers while minimizing iron deficiencies and adverse effects.

Keywords: Kernel blending, Iron fortification, Micronutrient-uniformity, Cooked rice

[1]National Institute of Post-harvest Management, Anuradhapura

* nimal.dharmasena@gmail.com

Use of Cyclodextrin to Remove Cholesterol in Milk and Its Effect on the Availability of Other Milk Constituents

Jayakody P.A.N.K., Mendis B.E.P.* and Gunawardana M.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

A strong positive correlation exists between serum cholesterol level and development of coronary heart diseases. Due to the effect of dietary cholesterol on serum cholesterol levels, people have a concern about the excess intake of cholesterol through food. Use of β-cyclodextrin to remove cholesterol from milk is a method tested in the dairy industry. However, it affects the availability of other milk constituents. The purpose of this study was to assess the effectiveness of β-cyclodextrin to remove cholesterol from milk under different conditions (cyclodextrin percentage, pasteurized milk with and without homogenization, mixing time and centrifugal force) and to assess the effect of cholesterol-cyclodextrin complex formation on the availability of other milk constituents (lactose, fat, solid non-fat, protein and salts). For this purpose, different percentages of β-cyclodextrin were added to milk, stirred and the mixture was then centrifuged. The upper and middle layers were analysed for milk constituents. Lieberman-Burchard method was used to quantify cholesterol and Lactoscan milk analyser was used to quantify the other milk constituents. In removing cholesterol from non-homogenized pasteurized milk, 2% β-cyclodextrin was effective. In removing cholesterol from pasteurized milk with homogenization, 1.5% β-cyclodextrin was effective and it resulted 51.3% and 55.9% cholesterol reduction in upper layer and middle layers of centrifuged milk respectively. Mixing of β-cyclodextrin (2%) for 5 min and centrifugation at 2000 rpm resulted the maximum removal of cholesterol from non- homogenized pasteurized milk and it exhibited 67.3% and 70.7% cholesterol reduction in upper layer and middle layers respectively. Levels of main constituents of milk were significantly affected ($p<0.05$) by this process. However, the ultimate effect was different depending on the milk constituent and the condition. Based on the results of this study it can be concluded that β-cyclodextrin can be used effectively to remove cholesterol from dairy products.

Keywords: β-cyclodextrin, Complex formation, Cholesterol, Milk constituents

[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama

* ereshamendis@agri.pdn.ac.lk

Validation and Determination of Pesticide Residues in Carrot Using GC-MS/MS Method

Krishiga R., Guruge K.P.G.K.T.[1] **and Madhujith T.***
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Accumulation of pesticide residues in fruits and vegetables has always been a matter of concern. Carrot is a highly popular vegetable in Sri Lankan cuisine. The objective of this study was to validate a method for multi-residue pesticide analysis by simultaneous determination and quantification of 30 pesticide residues in carrot samples. Carrot samples were extracted according to the multi-residue extraction procedure, QuEChERS method as per Association of Official Analytical Chemists (AOAC) official method 2007.01 through a single step buffered acetonitrile extraction and salting out liquid-liquid partitioning from water in the sample with $MgSO_4$ and clean-up was carried out by dispersive solid phase extraction. Extracted samples were analysed by Gas Chromatography Tandem Mass Spectrometry (GC-MS/MS) and the presence of pesticides was confirmed with retention time (RT) and multiple reaction monitoring (MRM) transitions. Pesticides present in the samples could be identified unambiguously by matching the RT and MRM data of the sample peak with that of the certified reference materials'. In the method validation, the average recoveries recorded for the pesticide compounds by spiking the samples at 3 levels of concentration, 10, 40 and 100 ng/mL were within the range of 70 - 120% except for few. Relative standard deviations were below 20% in intra-day analysis for all the compounds. Excellent linearity with coefficient of correlation greater than 0.995 was obtained for the calibration curves which ranged from 10 to 100 ng/mL. Limit of quantification for tested pesticides was 10 ng/mL. Therefore, the validated method can be efficiently applied for the analysis of real carrot samples with high reliability.

Keywords: Carrots, Gas chromatography, Mass spectrometry, Pesticide residues, QuEChERS

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[1]Government Analyst's Department, Battaramulla

* tmadhujith@agri.pdn.ac.lk

A Comparison of Two Types of E-Learning for Undergraduates in the Faculty of Agriculture, University of Peradeniya

Rupasingha M.D.S.C., Wickramasuriya H.V.A.* and Alahakoon P.C.B.
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The concept and use of E-learning became more popular and essential in higher education during the recent COVID 19 pandemic. But, there is a research gap about the factors affecting the effectiveness of e-Learning in University education in Sri Lanka compared to other developed countries. Hence, the main objective of this research was to evaluate the effectiveness of two types of e-learning on undergraduates' learning in the Faculty of Agriculture, University of Peradeniya. In addition, three other factors that can impact on the effectiveness of e-learning were also studied. The study was a quasi-experiment which was mainly based on a separate-sample pretest-posttest design. One hundred and sixty four students participated in the experiment. They were divided into six groups on a stratified random basis, and then they were directed to three treatments. (face to face learning, blended learning and 100% e-learning). Each treatment was replicated. Quiz papers were distributed to test the knowledge of students before and after learning. A second posttest was conducted to determine the effect on retention. Also, a questionnaire was used to obtain data related to attitude towards e-learning, peer influence and other personal characteristics. The dependent variable of the study was the knowledge of students. Data was analyzed using descriptive statistics, such as mean, standard deviation, and frequency distributions. Inferential statistics used were paired sample t-test, one-way ANOVA and multiple regression. Blended learning was seen to be more effective than face to face learning and 100% e-learning. And 100% e-learning was less effective than the other two learning methods. There was a negative peer influence on e-learning. Attitude towards e-learning and English proficiency did not have a significant ($p>0.10$) relationship with the effectiveness on e-learning.

Keywords: E-learning, Blended learning, Face to face learning, Peer influence, Higher education

* heshan54@gmail.com

An Exploration into Valukkaiaru Basin Social-ecological System in Jaffna Peninsula

Mahithaman K. and Anuradha J.M.P.N.*
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The dry zone of Sri Lanka boasts of a hydraulic civilization which has a history of over 2 millennia. However, some of the hydraulic societies and their irrigation systems, which have survived for many centuries, have not been fully understood. Valukkaiaru basin provides home for such a social system, which has not been adequately documented. This ethnographic research was aimed at studying the Valukkaiaru pond cascade system and its agrarian society as a distinctive social ecological system. The main objectives of this study were to identify the evolution of practices in management and conservation of the Valukkaiaru basin social ecological system (VSES), to list the main components of the VSES and to explore the human-environment interactions between the Valukkaiaru basin social system and the ecological system. The study was conducted in Alavatty and Kantharodai, which are two GN divisions located within the VSES. Affinity diagrams, journaling and interview schedules were used to collect data. Management of the VSES has been a responsibility of the beneficiary households for many centuries, although it is now more a government responsibility. The VSES has its distinctive characteristics based on both ecological and social components. Controls, slow variables and fast variables of the VSES were identified. People in the study population show many interactions with the ecological components of the VSES for food, health, economic activities and culture. The study documented the cultural beliefs and norms that have supported to maintain the system for many centuries. It was also learnt that changes in those norms and beliefs, along with other economic factors (e.g., demand for agricultural land after the end of war) challenge the stability of the VSES. This study lays a foundation for advanced studies to investigate the VSES and propose recommendations to ensure its future sustainability.

Keywords: Valukkaiaru basin social -ecological system, Controls, Slow variables, Fast variables, Interactions

* anuradhaj@agri.pdn.ac.lk

Analysis of Prognostic Genetic Markers in Pre and Post-Menopausal Breast Cancer Patients in Sri Lanka

Perera R.A.C.D., Jayasinghe V., Siriweera E.[1] **and Kodithuwakku S.P.***
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Breast carcinoma is the most common cancer type among females. Gene expression analysis in cancer tissues will provide an in-depth understanding on how the cancer behave and spread. Gene expression profiles could also be used as prognostic markers to predict the treatment outcomes of cancers. The expression of prognostic genetic markers in pre and post-menopausal breast cancer patients has not been properly evaluated among Sri Lankan patients. Therefore, the present study was conducted to identify differentially expressed genes between the cohorts of pre and post-menopausal breast cancer patients as the first step in identifying possible prognostic molecular markers. A total of 44 female patients who were histologically and cytologically confirmed with breast cancer were included in the study. RNA was isolated from the tissue samples and reverse transcribed. The relative mRNA expression levels of B-cell Lymphoma-2 (*BCL2)*, *BCL2* –antagonist of cell death (*BAD)*, and B cell Lymphoma-2-Associated-x protein (*BAX)* genes were evaluated using quantitative polymerase chain reaction (RT-qPCR) technique. 18srRNA gene was used to normalize the expression data. Results showed that, *BAD* mRNA expression in pre-menopausal breast cancer patients was significantly higher ($p<0.05$) than that in post-menopausal breast cancer patients in the cohort. The expression difference was independent of the clinic-pathological parameters. The *BCL2* mRNA expression in pre-menopausal breast cancer patients was higher than that in post-menopausal breast cancer patients and the difference was not significant ($p>0.05$). However, there was no difference between the expression of *BAX* gene in pre and post-menopausal breast cancer patients. Accordingly, there is a high possibility to use *BAD* gene expression as a prognostic genetic marker in pre and post-menopausal breast cancer patients in Sri Lanka. The findings need a verification with a large cohort as a follow up study.

Keywords: Breast cancer, mRNA expression, *BAD*, *BAX*, *BCL2*

[1]Department of Pathology, Faculty of Medicine, University of Peradeniya, Peradeniya
* surangap@pdn.ac.lk

Analysis of Soil Fungal Diversity in Dimbulagala Forest in Sri Lanka

Ranaweera N.A.K., Dandeniya W.S.* and Attanayake R.N.[1]
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Information on soil fungal diversity in forests in the dry zone of Sri Lanka is limited. A study was conducted to analyze soil fungal diversity in *Dimbulagala* forest reserve and to isolate fungi involved in complex carbon degradation. A database developed from metagenomic sequencing of ITS-1 region of 18S rDNA targeting soil fungi of a soil sample collected from *Dimbulagala* forest was analysed and functional importance of dominant species was documented. Diversity indices were calculated using sequences identified at 97% similarity threshold level. Three soil samples were collected from the same area to isolate complex carbon degrading fungi using modified growth media. In here, fungi were enumerated on Rose Bengal Agar (RBA), Sawdust Maltose Agar (SMA), Sawdust Agar (SA) and Litter Agar (LA) in spread plate technique. Abundance and diversity of colony forming units (CFU) in different growth media were recorded and fungi that could grow on SA were isolated. Selected 3 isolates were inoculated into sawdust placed in a sealed glass bottle and CO_2 emittance was measured over 2 weeks. A bottle containing un-inoculated sawdust was used as control. Out of 4,778 sequences assigned to fungi, only 1,303 sequences were identified with more than 97% similarity. The most dominant phylum was Ascomycota followed by Basidiomycota. *Fusidium griseum* and *Beltrania rhombica* were among the most dominant species. Shannon–Weiner diversity index was 3.69 and fungi evenness was 0.77. Culture based analysis revealed significantly lower (P<0.05) abundance of fungi in RBA (2.99 $\log_{10}$ CFU/g) compared to that in LA, SMA, and SA media (4.41, 4.02 and 3.96 $\log_{10}$ CFU/g, respectively). Two fungal isolates mineralized sawdust at a significantly (P<0.05) higher rate compared to control. The study confirmed that there is high fungal diversity in soil from *Dimbulagala* forest and the soil harbour fungi capable of degrading complex carbon.

Keywords: Soil fungi, Roach 454 pyrosequencing, Complex carbon, Dry zone forest, Sawdust

[1]Department of Plant and Molecular Biology

* warshisd@pdn.ac.lk

Analysis of Staple Diet and Drinking Water for Heavy Metals and Fluoride from CKDu Region of Girandurukotte

Thalagala H. N., Wimalasiri K.M.S.* and Chandrajith R.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Chronic kidney disease of uncertain etiology (CKDu) is a major health complecation in Sri Lanka, especially in North Central Province and Uva Province. This comparative study was conducted to determine whether there is a relationship among CKDu prevalence, the dietary composition and quality of water consumed in a population living in Girandurukotte area. A questionnaire survey was conducted to select CKDu and non CKDu populations representing the total area and composite diet samples and drinking water samples were collected from more than 60 individual households. Collected water samples were analyzed for the presence of fluoride while the diet samples were analyzed for the presence of minerals. Fluoride content was determined using a UV-visible spectrophotometer and the minerals were analyzed using Inductively Coupled Plasma Mass Spectrophotometer (ICP-MS). The mean value of fluoride in drinking water collected from CKDu and non CKDu populations were 0.7 mg/L and 0.02 mg/L respectively. Nine different heavy metals (Fe, Cu, Ni, Pb, Zn, As, Cd, Mn and Cr) and 5 different macro elements (Na, K, Ca, Al, and Mg) were identified in diet samples. Results indicate that fluoride content in water consumed by CKDu population exceeded the WHO recommendation. Mean concentrations of Zn, Fe, Pb and Ni in diet samples showed a significant ($p<0.05$) difference between CKDu and non CKDu populations.

Keywords: Fluoride, ICP-MS, Heavy metals, Diet, Drinking water

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[1]Department of Geology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka

* swarnaw@agri.pdn.ac.lk

Biodegradability of Biodegradable Plastic Films under Controlled Conditions in Field and Laboratory Experiment

Nuwanthika K.A.W., Ariyawansha R.T.K.[1] **and Karunarathna A.K.***
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Biodegradable plastic emerged as an alternative to petroleum based conventional plastics; however, the environmental fate of biodegradable plastic is less known. Thus, this study was conducted to assess the degradability of biodegradable plastic films (lunch sheets) through a decomposition test in the field and a modified ASTM D 5338 biodegradability assessment protocol. Degradability of three commonly available plastic films; *Natureplus* (Biodegradable lunch sheets), Green pack (Biodegradable lunch sheets), and LDPE lunch sheets (negative reference), and Cellulose filter paper (positive reference) were tested exposing to different soil environmental conditions for 45 days. Plastic films were treated by laying on top of fertilized soil, half-burring and fully burring at Meewathura Experimental station. The pattern of disintegration, mass reduction, volatile solid reduction and interactions among said exposure conditions were analyzed. Moreover, a modified experimental setup was developed to test the biodegradability cum composability based on ASTM D 5338 biodegradability assessment protocol. The photogrammetric observation revealed that biodegradable plastic undergoes rapid disintegration and deformation under all exposure conditions; however, LDPE showed a slower change. All plastic types showed a steady mass reduction over time but the volatile solid reduction was greater in biodegradable plastics indicating that those specimens undergo biodegradation in addition to physical and chemical decomposition. Further, change of volatile solid content correlated with sample type, environmental conditions, and the combined effect of these two factors at 5% significant level. In the laboratory, a low-cost reactor was successfully developed to evaluate plastic degradation according to ASTM D 5338 biodegradability assessment protocol. The developed system could be used to evaluate the biodegradable plastic material in the Sri Lankan market. Moreover, the study showed that biodegradability of plastic directly correlated with the environmental conditions and type of polymer material.

Keywords: Biodegradable plastics, Biodegradability, Degradation

[1]Solid Waste Management Research Unit, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya

* anujica@yahoo.com

Cadmium Phytoavailability for Rice as Affected by Soil Application of Biochar and Zinc Sulphate

Fernando K.S.U., Attanayake C.P.* and Dharmakeerthi R.S.
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rice (Oryza sativa L.) may uptake Cadmium (Cd) from soil and accumulate it. Zinc Sulfate is recommended as a fertilizer because Zinc (Zn) is deficient in major paddy grown soils in Sri Lanka. Zinc has an antagonistic effect on bioavailability of Cd to rice. Amending soils with biochar could reduce bioavailability of both Cd and Zn modifying competitive uptake of Cd by rice. A pot experiment was conducted to investigate the impact of amending soils with rice husk biochar (RHB) and addition of $ZnSO_4$ to soils in the presence of RHB on phytoavailability of Cd for rice. Soil had 0.25 mg/kg of total Cd. Three treatments at original soil Cd concentration: T1-Soil, T2-Soil+RHB, T3-Soil+RHB+$ZnSO_4$; and 4 treatments with added Cd to soil at the rate of 3 mg/kg of Cd/kg: T4-Soil+Cd, T5-Soil+Cd+RHB, T6-Soil+Cd+$ZnSO_4$, T7-Soil+RHB+Cd+ $ZnSO_4$ were included in the study. Rice husk biochar and $ZnSO_4$ were applied at the rates of 0.1 % (w/w) and 2.5 mg/kg, respectively. Total and Mehlich-3 extractable Cd and Zn in soil and total concentration of Cd in rice shoots and roots were analyzed. Fraction of Mehlich-3 extractable Cd in soil was significantly ($P<0.05$) lower at flowering and harvesting compared to that at transplanting in non-spiked treatments. Concentration of Cd in roots were 2-26 times higher than that in shoots. Amending soils with RHB did not change Cd phytoavailability for rice in both Cd spiked and non-spiked soils. Addition of $ZnSO_4$ significantly ($P<0.05$) increased enrichment coefficient (root Cd/soil Cd) in Cd non-spiked treatments. Ratio of shoot: root Cd were similar in spiked and non-spiked soils and was not affected by application of biochar and $ZnSO_4$. Addition of $ZnSO_4$ increased phytoavailability of Cd only in non-spiked soils. Application of $ZnSO_4$ to soils having 0.25 mg/kg of background level of Cd could increase Cd phytoavailability for rice.

Keywords: Biochar, Bioavailability, Cadmium, Rice, Zinc

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* chammiattanayake@gmail.com

Causation, Effectuation and Bricolage: A Study of Decision-making Logics of SMEs in Kurunegala District of Sri Lanka

Dharmasiri E.P.I.P., Kodithuwakku K.A.S.S.* and Jayaweera V.W.
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Access to finance is a challenge faced by SMEs in starting up and growing their businesses. Financial institutions look for causal logic of decision making by SMEs to assess their creditworthiness through evaluating the business plans submitted by them. Therefore, the overall objectives of the study were to investigate whether the SMEs strictly implement business plans they submit to banks to obtain loans (adopt causal logic) or whether they use other decision-making logics, and if so, what are the decision-making logics adopted by them and whether the adoption of those decision-making logics change with the owner and business characteristics. A sample of 95 randomly selected SMEs who have obtained loans by submitting business plans from a leading development bank in Kurunegala were surveyed with a pre-tested structured questionnaire. Data were analysed using descriptive statistics and MANOVA tests with follow-up ANOVAs. The findings revealed that SMEs do not always plan and strictly follow them. They adopt effectuation and bricolage as well. There is a significant difference ($p<0.05$) between SME owner's decision-making logic with age, age and gender interaction and prior experience in the business operation of the owner, stage and the size of the business. Younger business owners relied more on effectuation while older business owners relied more on causation. Younger-female owners adopt both effectuation and bricolage. Highly experienced business operators relied more on effectuation. Furthermore, the small-scale businesses and the businesses at their start-up stage heavily relied on effectuation and bricolage whereas medium-scale businesses and the businesses at the growth stage greatly relied on causation. Study warrants further research on the type of decision-making logics and business success. It could be recommended for financial institutions and policy-makers to support SMEs by incorporating the aspects of effectuation and bricolage into the evaluation of businesses rather than relying on causation.

Keywords: SMEs, decision-making logics, causation, effectuation, bricolage

* sarathsk@agri.pdn.ac.lk

Characterization of Intergenerational Social Mobility in a Rural Village in the Dry Zone of Sri Lanka: A Case Study in Mahakanumulla Cascade System

Savindya G.K.O., Weerasooriya S.A.* and Weerahewa J.
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The rate at which new generations move to higher socio-economic status compared to those of their parents is a reflection of the speed of development of a society. This phenomenon is termed as intergenerational social mobility and is explained using differences in incomes, occupation, and education levels between generations. This research characterizes intergenerational social mobility in an agrarian society in Sri Lanka taking Mahakanumulla as a case study. Log-log linear regression models were estimated to measure income mobility and probit and multinomial logistic regression models were estimated for measuring the occupation and education mobility respectively. Data gathered from a questionnaire survey conducted among 463 households in the Mahakanumulla Village Tank Cascade System was used for the estimation. The results of the estimation shows that the intergenerational income elasticity is 0.16 suggesting a relatively higher mobility. The regression coefficients for occupation mobility from the industry sector to the farming sector are positive and statistically significant ($P<0.05$) compared to the mobility within farming sector. The regression coefficient for intergenerational education mobility is positive and statistically significant ($P<0.05$). The findings indicate an upward intergenerational income mobility and education mobility. Contrary to observations on out-migration from agrarian societies, the findings provide an indication of moving from industry related occupations to farming in Mahakanumulla area. Further studies are recommended to examine the determinants of occupation mobility to ascertain whether structural barriers prevent out-migration and urban-rural migration. Targeted measures to enhance incomes and provide a better education and livelihoods for children are recommended as the community studied is characterized by low incomes, lower education levels and lesser skills compared to average Sri Lankan community despite its phenomenal income and educational mobility.

Keywords: Intergenerational social mobility, Intergenerational income elasticity, Income mobility, Occupation mobility, Education mobility

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* senal883@gmail.com

Community Perception of Property Rights and Incompatibility between *De jure* and *De facto* Rights: A Case Study in Mahakanumulla Cascade System

Silva P.S.H., Weerasooriya S.A.* and Weerahewa J.
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Property rights play a key role in natural resource management. Secure property rights incentivize conservation. However, there exist mismatches between property rights perceived by the communities (*de facto* rights) and property rights defined inside a legal framework (*de jure* rights) particularly over common properties. Such mismatches cause resource conflicts among users leading to degradation of natural resources. Ostrom and Schlager's 'bundles of rights' framework was used to studying mismatches between *de facto* and *de jure* rights of ecosystem components; village tank, *gasgommana*, and *kattakaduwa* in Mahakanumulla Village Tank Cascade System. Data on perceptions related to access, withdrawal, management, exclusion, and alienation rights for the three ecosystem components and on socio-economic factors were gathered using a survey conducted among 460 households. Information on *de jure* rights was extracted from the Enactment No.03 of 2009 North Central Provincial Irrigation Management under Irrigation Ordinance No.32, 1946. The analysis reveals that the *de jure* rights for access and withdrawal are not clear in government legislations, except for withdrawing timber and products from a village tank. Irrigation systems management and development committee for cascades holds the management and exclusion rights of the three ecosystem components even though the community exercises *de facto* rights. Alienation of resources is prohibited under the said Ordinance yet the community exercises *de facto* rights. Adults, who belong to large families, low-income households, and farmer families show a higher tendency for exercising *de facto* property rights. Probit estimations indicate that people tend to exercise more use rights compared to control rights. There is a higher tendency to exercise *de facto* rights to the village tank, followed by *gasgommana* and *kattakaduwa*. It is recommended to make the community aware of *de jure* rights. Legitimizing *de facto* rights should be considered as a policy option to enhance the conservation of natural resources.

Keywords: Common pool resources, Control and use rights, Socio-economic factors, Ecosystems, Village Tank Cascade System

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* senal883@gmail.com

Comparison of the Above-ground Biodiversity in Homegardens with and without Livestock in Jaffna District

Tishekesh K., Lowe A. and Silva G.L.L.P.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Homegarden can be defined as a complex sustainable land-use system that combines multiple farming components. A study was conducted to compare the above-ground biodiversity of homegarden with livestock (HL) and without livestock (HWL) in Jaffna, Kodikamam, Kankesanthurai and Delft divisional secretariats in Jaffna district. Data were collected from 80 homegardens (40 HL and 40 HWL), and were analyzed using excel and Stata 11 packages, where descriptive statistics were used for drawing inferences. Local cattle, Jersey crossbred, local goat, Jamunapari goat, village chicken and guinea fowl were the farm animal categories found in HL. Average milk production of cattle and goat were 5.5 L/day/cattle and 0.2 L/day/goat, and around 17.5% milk produced in households were consumed. Average egg production of the study site was 6.8 eggs/hen/month, and around 65.1% of eggs produced were consumed. Sales of milk, eggs, animals and manure contribute to household income in HL. When the representation of flora and fauna components of the homegardens were considered, mean value of total number of floral species of the study area was 0.7, whereas in HL and HWL it was 7.6 and 7.8, respectively and showed no significant difference. Presence of beetles, moths and white flies showed significant difference ($P<0.05$) between HL (93.33%, 72% and 70%) and HWL (6.67%, 28% and 30%). Mean value of Shannon-Wiener diversity index of woody tree species was 0.6 in the study area, where HL and HWL showed 1.17 and 1.19 diversity levels, respectively. Average household dietary diversity score of HL and HWL were 7.95 and 8.02, respectively. The average household food insecurity access scale of HL and HWL were found to be 0.062 (HL) and 0.060 (HWL), respectively. Presence of livestock in homegardens have influenced only on the diversity of certain category of species in the study area, in addition to provision of additional income.

Keywords: Biodiversity, Comparison, Homegarden, Livestock

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* pradeepas@pdn.ac.lk

Compatibility between Expectations of Small-sector Fishing Community and Performance of the Political Leaders in the Hambantota District, Southern Province

Piyumal W.P.A. and Alahakoon P.C.B.*
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The fisheries sector is crucial to Sri Lankan society as well as for the economy and contributes 2% to the GDP of the island. The Sri Lankan fisheries sector consists of three main subsectors. They are, coastal (offshore, and deep sea), inland, and aquaculture. In Small-scale fisheries, fishermen go fishing individually in boats or they work in small groups. The present study was conducted in Hambantota district, with the objective of comparing the expectations of small-scale fishing community with the performance of political leaders in Hambantota District. The study was conducted to compare the Leadership Styles and Big Five Personality Factors of the politicians and expectations of fishermen. Two studies were conducted with randomly selected 40 fishermen from three GS areas namely Tangalle, Rekawa and Hambantota and 34 politicians from Parliament, Provincial Councils, *Pradeshiya Sabhas* and Urban Councils. A cross sectional study was undertaken using structured questionnaire schedules with a total of 74 respondents. The findings reveals the current situation of the fishermen expectations and present politicians' performance. There was a huge gap between males and females who were engaged in fisheries and political sectors. All of the fishermen were male. All of the fishermen had only studied up to GCE O/L. There was a significant difference ($P<0.05$) of perception between the two sample groups related to all 3 leadership styles, namely authoritarian, democratic, and laissez-faire. In personality types also, all the traits namely extraversion, agreeableness, conscientiousness, openness to experiences, and emotional stability were significantly different ($P<0.05$) for both groups. Furthermore, perception on all problems related to the fishing community was significantly different ($P<0.05$) in both groups.

Keywords: Small-scale fishing community, Leadership styles, Big five Personality Factors

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* prasadb@agri.pdn.ac.lk

Design and Evaluation of a Smart Groundwater Monitoring System (SGMS) for Kalpitiya Peninsula

Jayasundara R.B.C.D., Diyawadana M.[1] **and Padamarajah S.***
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Objective of this study was to design and evaluate an affordable Smart Groundwater Monitoring System (SGMS) that can be used to monitor shallow aquifers and used as a groundwater management tool. A SGMS was developed to facilitate farmers to get the real time information about the groundwater depth and quality and provide data for continuous monitoring of groundwater. The system composed of an aTmega 328 micro controller and programmed for farmers to get information on groundwater depth and electric conductivity to their mobile phone through short message service (SMS). Water level sensor (Ultrasonic sensor water proof JSN- SR04T-2.0) was used in measuring the groundwater depth from the surface and Electric Conductivity sensor(Apure online EC sensor / EC controller / EC probe for conductivity meter) was used in measuring electric conductivity of groundwater. The farmers can connect with the SGMS through short message services via their mobile phone and GSM modular (Sim 900 – GPRS GSM Modular) in the system. The system was tested for its ability to receive message to the system and transmit the sensed data to the mobile phone. The values obtained with the sensor showed high correlation with the actual water depths measured in the field ($y = 0.9972$ sensor value $(x) + 0.6347$ with $R^2 = 0.9999$). At present farmers in Kalpittiya have no facilities to get real time information of groundwater quality. The designed SGMS will facilitate farmers to obtain real time data to their mobile phones. Also, this system can be used to get real time information on groundwater level and quality from any shallow wells.

Keywords: Coastal sand aquifer, GPRS GSM modular, Monitoring, Water level, Water quality

[1]Agricultural and Agrarian Insurance Board

* spathma@pdn.ac.lk

Detailed Characterization of Leaf Gas Exchange and Associated Leaf Traits in Dry Mixed Evergreen Forest in the Dry Zone of Sri Lanka

Sewwandi K.G.D.T., Weerasinghe K.W.L.K.* and Geekiyanage N.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The effect of canopy position on leaf structural traits (LMA), leaf gas exchange rates including light saturated photosynthetic rate (A_{sat}), light and CO_2 saturated maximum photosynthetic rate (A_{max}), leaf respiration in the dark (R_D), leaf respiration in the light, and temperature sensitivity of the leaf dark respiration (Q_{10}) in 18 canopy tree species were determined in a tropical dry mixed evergreen forest located in Dambulla, Sri Lanka. Exploring the relationship between short-term changes in temperature on leaf respiration in a tropical dry mixed evergreen forest in Sri Lanka is the novelty in this study. Results showed significantly higher LMA values in the upper canopy (119 ±9 gm^{-2}) (p<0.05) when compared to the lower canopy (74±11 gm^{-2}). Area-based rates of A_{sat}, A_{max} and R_D (measured at 30 ºC) were also significantly higher in the sun exposed upper canopy leaves when compared to the lower canopy indicating higher metabolic capacity in the upper canopy. The respiration in light (R_L) was lower than that in the dark (R_D) (30 ºC) in both canopy positions indicating that light inhibits the leaf respiration. However, the degree of light inhibition (D-LI) did not vary significantly between two canopies, when averaged light inhibition of 33% was found across both canopies. Within the 25-40 ºC measurement range, both upper and lower canopy demonstrated a declining trend in temperature sensitivity of leaf respiration (Q_{10}) with Q_{10} value of 2.12±0.05 at the room temperature (*i.e.* at 25 ºC) and 1.96±0.02 at 30 ºC, for the whole canopy. The results revealed that the respiration increases at a decreasing rate with increasing leaf temperature leading to less CO_2 emission at higher leaf temperatures. These findings have important implications for vegetation climate models that seek to predict carbon fluxes between tropical dry forests and the atmosphere.

Keywords: Canopy, Leaf gas exchange, LMA, Q_{10}, Tropical dry mixed evergreen forest

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[1]Department of Plant sciences, Faculty of Agriculture, Rajarata University of Sri Lanka, Anuradhapura, Sri Lanka

* lasanthaw@pdn.ac.lk

Development of an Index to Assess Farmer's Potential for Purchasing Heavy Machinery in Paddy Cultivation

Madusanka N.G.N.V., Mowjood M.I.M.*, Dayawansa N.D.K., Silva F.H.C.A. and Bopeththa C.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Farm machinery usage in paddy cultivation has increased in past few decades due to labour scarcity and increasing labour wages in Sri Lanka. Among machineries used in paddy cultivation tractors and combine harvesters play a major role in total cultivation process since land preparation and harvesting are the most labour intensive, drudgery and time consuming practices. However, the mechanization in paddy cultivation is under its potential due to various reasons. A study was conducted to develop an index to identify farmer's potential for purchasing heavy machinery used in paddy cultivation. A pre-test questionnaire survey was carried out for criteria selection and sample collection to analysis among randomly selected 61 farmers who are with and without heavy machinery in 10 district secretariat in Anuradhapura district. Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) statistical methods were used to analysis data. There were 28 criteria were taken to analysis under economic and social categories. According to PCA results, from first 10 principal components didn't show at least 80% of cumulative variance therefore each variable had significant contribution to total variance hence LDA was used to develop the index. The dividing point value C of LDA was 7.452 and used to divide respondents into 2 groups, potential and not potential for heavy machinery. It was found that 5 variables were not significantly contributes to the model. The index value in this study ranges from -8.244 to 7.899. The positive values of the index came from farmers with heavy machines. The index was validated with 17 respondents. The developed index can be used directly to measure a farmer's potential on buying heavy machinery with 88.24% accuracy. The developed index should be extended with more respondents to increase the accuracy.

Keywords: Combine Harvesters, Heavy machinery, Index, Purchasing, Tractor

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[1]Hayleys Agriculture Holdings Limited, Colombo 10.

* mmowjood@pdn.ac.lk

Development of an Organic Liquid Fertilizer from Jackfruit Peel Waste and Assess Its Effects on Growth of Capsicum in Protected Agriculture

Abeysinghe A.A.D.K.N. and Dharmakeerthi R.S.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

In this study, a technology to produce an organic liquid fertilizer from underutilized jackfruit peel waste was developed and its effectiveness in protected agriculture was assessed. The leachate derived from vermicomposted jackfruit waste (VCL) using *Hemetia illucens* (black soldier fly larvae) and *Eisenia foetida* (epigeic earthworm) was analyzed for its chemical properties. A pot experiment was carried out in a protected house to determine the effect of undiluted or diluted VCL application, supplemented with or without synthetic N and P fertilizers on growth parameters of capsicum *var*. 454 F1. Six treatments (T1-water only, T2-Albert's solution, T3-1:3 diluted VCL supplemented with N and P, T4-1:3 diluted VCL, T5-Undiluted VCL supplemented with N and P and T-6-undiluted VCL) were applied to capsicum plants grown in coco pith based grow bags. The K content in undiluted VCL was very high (2398 mg/L) resulting in a high EC (0.625 S/m) and a high pH (8.72). Content of other plant available macro nutrients such as N, P, S and Mg were low (42, 77, 3.7 and 70 mg/L, respectively). The VCL also contained some micro nutrients such as Mn (0.07 mg/L), Fe (1.16 mg/L), Zn (0.06 mg/L) and Cu (0.03 mg/L) in addition to 0.25% of humic acid content. Significantly high ($P<0.05$) SPAD meter reading, number of leaves and plant growth could be observed in treatments with VCL added with synthetic fertilizers, compared to VCL only treatments. Further T2 and T3 have shown significantly higher (92.65%) pod yield over T5. This study revealed that VCL made only with jackfruit peel waste cannot be used as a fertilizer without being supplemented with N and P and that 1:3 dilutions of VCL is necessary to obtain comparable growth and yields from capsicum plants grown in coco-pith based growbags in protected agriculture.

Keywords: Vermicompost, Jackfruit, Black soldier fly, Protected agriculture, Organic liquid fertilizer

* dharmakeerthirs@gmail.com

Distribution of Different Forms of Organic Nitrogen within the Profile of Reddish Brown Earth (RBE) Soils of Cultivated and Uncultivated Fields

Jayakody J.A.S.H. and Nandasena K.A.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Distribution of different forms of organic nitrogen (N) within a profile of Reddish Brown Earth (RBE) soils of cultivated and uncultivated fields from *Mahailuppallama,* Sri Lanka were investigated. Representative soil samples were collected from 0 – 15, 15 – 30 and 30 – 45 cm depths and subjected to N fractionation as described by Stevenson (1982) following acid hydrolysis. Different forms of organic-N; ammonium-N, amino sugar-N, amino acid-N, hydrolysable unknown–N, total hydrolysable–N and acid insoluble–N were determined. There was a significant difference ($P<0.05$) in total N between cultivated and uncultivated fields at different depths except 0 – 15 cm depth. Total N content was in decreasing trend with the depth in both fields. In cultivated and uncultivated soils, total acid hydrolysable-N fraction varied from 30 – 34 % and 28 – 32 %, respectively. Significantly high hydrolysable-N content was observed at all three soil depths of cultivated field. Long-term cultivation with application of fertilizers may have increased hydrolysable N in cultivated field. Ammonium-N and amino sugar-N at three soil depths were not significantly different ($P>0.05$) in cultivated and uncultivated fields. Amino acid-N was significantly ($P<0.05$) high in uncultivated soil compared to cultivated soil only at 0-15 cm depth. But percentage distribution of this fraction from total-N was high in cultivated soil. Acid hydrolysable unknown-N ranged from 5.61 – 7.14 % in soils from cultivated field and from 8.52 – 10.36 % in soils from uncultivated field. Acid hydrolysable unknown-N fraction was not significantly different ($P>0.05$). Relatively high N contents were recorded in uncultivated soils compared to cultivated soils. At all soil depths, main organic-N form was amino acid-N followed by ammonia-N. Least percentage distribution was observed for amino sugar-N. This study revealed that cultivation of soils changed organic-N distribution in the profile of RBE soils.

Keywords: Organic nitrogen, Soil profile, RBE soils, Cultivated fields, Amino acid nitrogen

* nandasenakalahe@gmail.com

Distribution of Organic Nitrogen Fractions in Reddish Brown Earth Soils in Cultivated and Uncultivated Fields

Hewawellage U. N. L. and Nandasena K.A.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Different organic nitrogen (N) fractions in Reddish Brown Earth (RBE) soils, that had been cultivated continuously for decades compared to that in the uncultivated fields from *Mahailuppallama,* Sri Lanka were investigated. The fields were divided into three drainage classes: well-drained, moderately-well-drained and imperfectly-drained, before taking soil samples from 0–20 cm depth. Soil samples were subjected to N fractionation as described by Stevenson, 1982. Different organic N forms: ammonia-N, amino sugar-N, amino acid-N, hydrolysable unknown-N, acid insoluble-N, and total hydrolysable-N were determined. The total N contents varied from 756 to 392 mg/100 g in cultivated fields and from 420 to 336 mg/100 g in uncultivated fields. The extractability of total hydrolysable-N was about 12-19 % in cultivated fields and 23-26 % in uncultivated fields, respectively, even though total N was high in cultivated field. The acid insoluble N fraction was ranged from 80.36 % - 87.70 % in cultivated fields and from 73.33 % - 76.19 % in uncultivated fields. Acid hydrolysable unknown-N ranged from 3.31 % - 4.42 % in cultivated fields and from 6.25 % - 11.83 % in uncultivated fields, respectively. Significantly low ($P<0.05$) N contents in hydrolysable and hydrolysable unknown fractions in cultivated fields could be attributed to the decline of N due to intense crop cultivation. Neither ammonia-N, amino sugar-N nor amino acid-N was significantly different ($P<0.05$) in the cultivated and uncultivated fields. All the N fractions were not significantly different ($P<0.05$) among three drainage classes. Main organic N form of soil was amino acid-N, followed by ammonia-N separated from acid hydrolysis. Least percentage distribution was given by amino sugar-N which was ranged from 0.1 % - 1.5 % in both types of fields. This study revealed that cultivation have changed the distribution of organic-N fractions in RBE soils.

Keywords: Organic nitrogen fractions, Total nitrogen, Acid hydrolysis, Cultivated fields, Uncultivated fields

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* nandasenakalahe@gmail.com

Diversity and Activity of Soil Microorganisms as Affected by Intensive Cultivation Practices in Up-country of Sri Lanka

Kekuladale M.S.S., Upekshani H.A.N.[1], Dandeniya W.S.* and Dharmakeerthi R.S.
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

In intensive crop production 3 to 4 crops are grown per year with frequent disturbances to soils. A study was conducted to assess the effect of intensive cultivation practices on nutrient availability, C mineralization, and bacteria abundance in soils. From an agricultural landscape in Nuwara Eliya district in Sri Lanka, 24 sites including 12 agricultural fields under intensive vegetable cultivation, 8 tea cultivated fields and 4 sites in the boundary of adjacent forests, were selected. Three litter bags containing known weight of cellulose papers were placed at 5cm depth at each site and recovered after one month to determine percent weight loss. Soil samples were collected in triplicates and analyzed for bulk density, pH, Electrical Conductivity (EC), available nutrients, organic C, total N, abundance of total bacteria (TB), and bacteria resistant to amoxicillin (10 ppm) and tetracycline (10 ppm). Soils from intensively cultivated fields were considered as frequently disturbed (FD), while soils from tea plantations and forest boundaries were considered as less disturbed (LD) for statistical comparison using pooled t-test at $P<0.05$. Frequent disturbances to soil significantly increased ($P<0.05$) cellulose decomposition, pH, available P, bulk density, abundance of TB and amoxicillin resistant bacteria population (ARB), while it significantly decreased ($P<0.05$) moisture content, active C, total C and total N. Mean weight loss of cellulose papers in FD and LD soils were 66 % and 34 %, respectively. In LD soils, total C and active C contents were 6.33 % and 1,002 mg/kg, respectively; whereas those in FD soils were 1.95 % and 580 mg/kg, respectively. In conclusion, intensive cultivation enhanced available P, C mineralization and TB abundance in studied soils, while reducing total C content. High C mineralization potential in intensively cultivated fields suggest that these soils may be contributing more to global warming than LD soils.

Keywords: C mineralization, intensively cultivated fields, total C, antibiotic resistance, soil disturbance

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[1]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya

* warshisd@pdn.ac.lk

Diversity of Soil Fungi and Cellulose Decomposers Associated with Organic Matter Decomposition in Soils under Vegetable Cultivation and a Montane Forest

Subhashini A.S.R. and Rajapaksha R.M.C.P.*
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Microbial-mediated organic matter decomposition contributes approximately 8 % of the annual additions of atmospheric carbon dioxide (CO_2) pool. A study was conducted to assess the diversity of fungi and cellulose decomposers and CO_2 emissions from soils under vegetable cultivation in Nuwara Eliya and montane forest in Horton plains at ambient and 35 ^oC temperature. Disturbed soil and undisturbed soil core samples were collected from 12 vegetable cultivated fields, applied with either compost, poultry manure (PM) or cattle manure (CM) along with chemical fertilizers and from rhizosphere of five endemic and two invasive plant species in forest. Disturbed soils were analyzed for pH, labile carbon (C) and soil organic matter (SOM). Populations of fungi and cellulose decomposers were enumerated using plate count method. Carbon dioxide emission was quantified using fresh soils at 28 $^oC\pm2$ and after warming a subset of soil over two weeks at 35 ^oC. In comparison to agricultural soils, forest soils had more acidic pH (5.3-6.1), labile C (1120-1329 mg/kg), higher SOM (6-14 %) and CO_2 emission. Populations of fungi and cellulose decomposers and predominant spp. differed between agricultural soils added with different amendments and forest soils under different plant spp. at ambient and heated temperatures. The CO_2 evolution was generally higher in CM amended soils at both temperatures. After warming, generally CO_2 emissions were increased, but reductions were observed in a few CM and PM added soils. Soils under endemic tree spp. showed the highest CO_2 emission at both temperatures. Following warming, CO_2 emissions increased from soils under *Rhododendron arboreum* and another three plant spp. Correlations suggested that CO_2 emission from forest soils were governed by moisture content ($r=0.64$, $P<0.01$), and labile C ($r=0.68$, $P<0.05$); and a similar trend was observed in agricultural soils, though the correlations were not strong.

Keywords: Agricultural soil, CO_2 emission, Forest soil, Labile C, Temperature

* chandir@pdn.ac.lk

Do Inoculation of Effective Microorganisms (EM-1® or Effective Microorganism®) and Nitrogen Supplementation Accelerate the Elephant Dung Decomposition?

Rathnapala P.G.P.K., Vidanarachchi J.K.*, Dandeniya W.S.[1], Bandaranayake L.[2], Nayanajith A.[2] and Perera A.N.F.
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Main objectives of this study were rapid decomposition of elephant dung (ED), evaluation of phytotoxicity and plant nutrients. Composting process consisted of four compost mixtures, mixture 1 (ED alone), mixture 2 (ED + urea 1.0% W/W), mixture 3 (ED + EM 1.0% V/W) and mixture 4 (ED + urea 1.0% W/W + EM 1.0% V/W). Each compost mixture was quadruplicated. Effective microorganisms (EM) inoculated on the starting day and 16th day. Nitrogen supplemented (through urea) on starting day. Composting process studied in terms of temperature, pH, electrical conductivity (EC) at 4 days intervals and C:N ratio at 10 days intervals during 45 days composting period. At 45 days of composting, phytotoxicity of composting mixtures were evaluated with a germination bioassay, and a plant growth bioassay conducted to evaluate plant nutrients, and coliform bacteria abundance was determined by serial dilution technique. Data subjected to Analysis of Variance under Complete Randomized Design using SAS 9.0 and means were separated by Tukey's test at $P<0.05$. All compost mixtures showed neutral to weakly alkaline pH profiles. Compost mixture 4 had the highest ($P<0.05$) EC profile in the last eight days of composting period. Compost mixtures 2 and 4 had the optimum C:N ratios of 26:1 and 22:1 respectively at the end. In germination bioassay, germination percentage of compost mixture 2 was 100%. Relative radicle growth of compost mixture 1 was the least ($P<0.05$). Compost mixture 3 had the highest seed tolerance index. Compost mixture 2 and 4 were shown higher ($P<0.05$) plant heights at the end of 40 days of the plant growth bioassay. Compost mixture 1 had the highest ($P<0.05$) coliform count. Inoculation of EM in combination with nitrogen supplementation accelerated the ED composting with low phytotoxicity, high status of plant nutrients with a higher status of hygiene.

Keywords: Elephant dung, Effective microorganisms, Composting, C:N ratio

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[1]Department of Soil Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
[2]Sarwodaya Sustainable Economic Enterprise Development Services Limited

* janakvid@pdn.ac.lk

Effect of Socio- economic Factors on the Adoption of Good Agricultural Practices by Vegetable Farmers in Nuwara Eliya District

Bandara T.M.W.G.V.Y. and Jayawardena L.N.A.C.*
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Good Agricultural Practices (GAP) is one of the major concepts introduced by the Food and Agriculture Organization of the United Nations to ensure the safety and quality of foods. It was introduced to Sri Lanka in the year 2015 as Sri Lankan GAP (SL-GAP) implemented by the Department of Agriculture. Only 750 vegetable farmers in Sri Lanka have obtained the GAP certificates. The general objective of the study was to examine the effect of socio-economic factors on the adoption of good agricultural practices by vegetable farmers in Nuwara Eliya District. The effect of socio- economic factors on the adoption of GAP was analyzed separately among SL GAP certified farmers and non- certified farmers. Conceptual framework of the study was based on the innovation diffusion theory. The key socio- economic factors related to the farmers' adoption of practices were identified through literature review. Education of farmers, farming experience, farmers' agricultural background, ownership of the cultivated land, extent of cultivated land, perceived benefits from agriculture and satisfaction of extension service were identified as key socio- economic factors. The adoption of SL-GAP was measured using a scale developed by the Department of Agriculture. The sample size of SL GAP certified farmers was 30, and 60 farmers were selected among the non- certified farmers. Inferential analyses were conducted in the form of multiple linear regressions, and Welch test. etc. According to the regression results, there was a positive effect of the extent of cultivated land on the adoption of SL-GAP by certified vegetable farmers. There was a positive effect of educational level on the adoption of SL-GAP by non- certified farmers. The involvement of farmers in agricultural activities had an effect on the adoption of SL-GAP. The background of farmers (traditional & non-traditional) has also influenced the adoption of SL-GAP by non- certified farmers.

Keywords: Good agricultural practices, Adoption, Socio-economic factors, SL-GAP certified farmers

* chandanacj@gmail.com

Ethnobotanical Survey of Underutilized Edible Species in Three Selected Villages in The Neighborhood of Ritigala Strict Nature Reserve

Athauda A.S.K., Ranil R.H.G.* and Wijerathna R.M.S.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Cultivation and utilization of underutilized species are gaining popularity in many countries with the realization of their enormous potential to serve the mankind. In Sri Lanka, these species have been heavily used by the traditional societies to meet their daily needs but it has got rather low with the present generations. Thus, ethnobiological studies are of paramount importance in collecting and preserving indigenous knowledge associated with these underutilized species. Thus, an ethnobotanic survey was conducted to investigate the diversity and depth of Knowledge, Attitudes and Practices (KAP) pertaining to Underutilized Edible Species (UEs) by the community living in the vicinity of the Ritigala Strict Nature Reserve(SNR). Hundred rural women from three (03) nearby villages were randomly selected for the study. Study was carried out using the standard ethnobotanical methods. Data were collected through semi-structured interviews and analyzed using quantitative indices, Fidelity Level (FI) and Relative Frequency Citation (RFC). The study identified 104 UEs belonging to 51 families, of which, 57% are indigenous to Sri Lanka. The family Cucurbitaceae was the dominant family with 12 species. The highest RFC values were recorded for *Lasia spinosa* (1.0) followed by *Solanum insanum* (0.98) and *Benincasa hispida* (0.94). The highest FI values were recorded for *Lasia spinosa* (0.52) and *Solanum insanum* (0.51). Results of KAP analysis revealed that the tradition of using UEs for meeting basic needs still exists among the local community, though it is declining rapidly. Moreover, 92%, 68% and 46% of respondents claimed that lack of awareness, availability and, poor knowledge and interest of the younger generation are major impediments to popularize UEs, respectively. Community indicated the importance of cultivation and sustainable utilization as a means of conserving the UEs and associated knowledge. Study identified that community is not causing significant impact on Ritigala SNR due to extracting of UEs.

Keywords: Ethnobotany, Underutilized species, Ritigala SNR, Traditional knowledge

[1]Department of Agricultural Extension, Faculty of Agriculture, University of Peradeniya, Peradeniya

* rhgranil@gmail.com

Evaluating the Effectiveness of Mobile Journalism Training in Improving Knowledge and Practice among Young Journalists in Sri Lanka

Kavindya A.K.G., Dissanayeke U.I.*, Wijerathna R.M.S. and Wanigasundera W.A.D.P.[1]
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

A leading Non-Government Organization in Sri Lanka has conducted Mobile Journalism (MoJo) training programs for aspiring young journalists since 2018. However, the effectiveness of these training programmes had not been assessed in a scientific manner. Hence, this study was conducted to evaluate the effectiveness of this MoJo training using Kirkpatrick's training evaluation model. Accordingly, the participants' reaction to training, knowledge gain, and practice of MoJo after the training were assessed. Data were collected from three groups; participants of an ongoing training program (n=30), journalists who had completed the same training in 2018 (n=32), and a control group of non-participants for a similar training (n=30). Separate questionnaires were used to assess reaction, knowledge gain, and behavioral changes. Data were analyzed using descriptive and inferential statistics. Observations, key informant discussions and follow- up interviews were also used for methodological triangulation. According to the findings, within a range from 1 to 5, mean overall reactions were satisfied with training content (4.546), knowledgeability of trainers (4.355), training schedule (4.383), teaching materials and methods (4.408) and training environment (3.850). The results for pre-test and post-test showed that the participants' learning had significantly improved after the training ($P<0.01$, $t=8.495$). Moreover, the results indicated that the participants' reaction was positive and significantly related ($P<0.05$) to the learning. The results showed that there was a significant difference between the participants and the non-participants with regards to the number of MoJo productions, production frequency and approximate duration. It can be concluded that the training program has improved the knowledge and practice with regard to MoJo among the participating journalists, and was successful in imparting knowledge and skills among the participants. Increasing the frequency of training, selecting the most suitable sessions, and allowing the participants to suggest the required training materials before starting the training are recommended for future trainings.

Keywords: Training evaluation, Kirkpatrick's model, mobile journalism, young journalists

[1]Sri Lanka Development of Journalists Forum, Swarna Place, Nawala Road, Rajagiriya

* uvasarad@gmail.com

Evaluation of Homegarden Practices and Vegetation at Karachchi, Kilinochchi District with Special Reference to Changes after 2012

Mugunthan V. and Hitinayake H.M.G.S.B.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Homegardens in the dry zone perform important ecosystem functions like their counterparts in the wet zone. The structure and composition of the system strongly correlate in performing the above roles successfully. After ending the war in the Northern districts including Kilinochchi government launched several programmes to assist the livelihood development including assistance to homegarden cultivation. Further, Kilinochchi is a diverse region in terms of water availability and soil conditions. The objective of this study was to evaluate homegarden practices and vegetation in relation to groundwater availability and soil conditions. Special emphasis was placed upon the changes took place after ending the war in 2012. Forty-five homegardens in Karachchi Divisional Secretariat division in the Kilinochchi district were selected for the study with the stratification based on soil types and access to groundwater. A vegetation study and a questionnaire survey were done to evaluate the structure and composition of homegardens and household information, respectively. Results revealed that the areas with Red Yellow Latasol soil and high water table have the high stocking density and a high number of species diversity whereas Red Yellow Latasol soil with low water table showed lower values. This shows that the highest impact on stocking density is by the height of the water table not by the soil type. The most common (highest Relative Density) species were Coconut and Arecanut. The most widely distributed (highest Relative Frequency) species were Coconut and Mango. The dominant species varied with soil type. In the Red yellow latosol, it was Coconut, Arecanut and Mango whereas in the Solodized Solonetz soil it was Coconut, Mango and Palmyrah. The study also showed that new planting has taken place in 31% of homegardens after resettlement in 2012.

Keywords: Dry zone homegardens, Kilinochchi district, species diversity and dominance

* gaminih@pdn.ac.lk

Evaluation of Restoration Methods of Pine Plantation Adjacent to Natural Forest in Buffer Zone of "Sinharaja World Heritage"

Ranasinghe W.M.I.K., Pushapakumara D.K.N.G.* and Premakantha K.T.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The natural forest cover of Sri Lanka is decreasing at a rapid rate due to many reasons. Therefore, Sri Lanka is planning to increase the national forest cover up to 32% by 2030 in agreement with the Nationally Determined Contribution to UN Framework Convention on Climate Change in 2016. To achieve this national target and to find a cost effective and sustainable method for conversion of pine (*Pinus caribaea*) plantations in to diverse broad leaves vegetation, the Forest Department of Sri Lanka were experimented with six methods in 2015 at Kahagala research block in Kamburupitiya forest range in Matara, Sri Lanka adjacent to Sinharaja World Heritage site. Six treatments were assessed after five years from establishment by estimating the status of biodiversity, stand structure, production, and cost estimation for conducted treatments. Evaluated treatments were undisturbed *P. caribaea* plantation with regeneration (T1), rind barked of *P. caribaea* trees with old regeneration (T2), newly planted stand with *Dipterocarpus* spp. and mixture of indigenous species [after clear felling of *Pinus* (acfp) and other vegetation] (T3), natural succession without disturbances over 5 years, acfp (T4), natural succession and patches has cleared around regenerating plants annually over 5 years, acfp (T5), natural succession and patches has cleared around regenerating plants and low slashing annually, acfp (T6). Estimated variables were analyzed to obtain descriptive statistics. T1 and T2 were better than others in terms of diversity, stand structure, relative abundance of invasive individuals, production and cost effectiveness. T3 was always poor than naturally regenerated stands. T5 and T6 were more prone to invasion of invasive species than others. Hence, it is recommended to accelerate natural regeneration by felling of *P. caribaea* without clear felling of entire area or removing the timber without damaging to natural regeneration.

Keywords: Pine plantation, Regeneration, Restoration, Sinharaja MAB

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[1]Conservator of Forest , Geo-information & Forest inventory, Forest Department , Rajamalwatta road, Battaramulla

* ngpkumara@pdn.ac.lk

Farmer Perception on Banning of Glyphosate and Alternate Techniques Used to Control Weeds in Paddy and Maize Cultivations

Abeyrathna M.G.N.S.G., Marambe B.*, Suriyagoda L. and Rathnaweera S.N.L.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The farmer-perception on banning of Glyphosate, a time-tested tool for pre-plant weed control, and alternate techniques used by farmers for weed control in paddy (*Oryza sativa* L.) and maize (*Zea mays* L.) cultivations were studied. Primary data were collected using a pre-tested structured questionnaire, coupled with individual discussions with 80 randomly selected farmers in four *Grama Niladhari* Divisions (GND) in the Anuradhapura district of Sri Lanka. From the district, two agriculture-based Divisional Secretariat Divisions (DSDs) were selected purposively and two GNDs were selected randomly from each DSD. The selected areas were Ihalagama and Maradankalla GNDs from Mihinthale DSD and Mawathwewa and Endagala GNDs from Thalawa DSD. About 85% of farmers have used Glyphosate prior to its ban, and the usage has increased with increased farmland size. However, after the ban, 43% of the respondent farmers still use unregistered Glyphosate products with majority being the maize-growers (56%) than the paddy-growers (41%). All respondent farmers in the Maradankalla GND have stopped using Glyphosate after the ban as they perceived negative effects on the environment (100%) and human health (32%). However, majority of those in Mawathwewa and Ihalagama GNDs have continued to use unregistered Glyphosate products, as more farmers cultivated maize. Only 50% of the study sample supported the ban, while 94% had their cost of weed control increased and all reported that the time spent on weed control has increased after the ban. However, no farmer reported of significant yield reduction of paddy and maize during the period of ban Glyphosate, as they have used alternate techniques such as grass cutter (72%), 4-wheel tractor with disc plough (18%), other herbicides (12%), self-preparations (7%), etc., to control weeds. The ban imposed on Glyphosate has not yielded expected results as farmers still search for, and use unregistered Glyphosate products especially for maize cultivation.

Keywords: Glyphosate, Herbicide ban, Maize, Paddy, Weed control

[1]Office of the Registrar of Pesticides, Gatambe, Peradeniya, Sri Lanka

* bmarambe@pdn.ac.lk

Fractionation of Inorganic Phosphorus in Reddish Brown Earth Soil of Long Term Cultivated and Uncultivated Fields of Dry Zone of Sri Lanka

Sabaragamuwa K.C., Nandasena K.A.* and Palihakkara P.D.B.J.
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Global Phosphorus (P) demand has been steadily increasing with the increasing population in the world. Understanding the forms of P in soils is essential to make reserved P in soils available to plants. This study was conducted to determine soil P fractions in long-term cultivated and uncultivated fields at Field Crop Research and Development Institute (FCRDI) in Mahailluppallma. Thirty six sampling points were selected, randomly along the catena of the 2 parallel fields. Topsoils (0-30 cm) from each sampling points were subjected to sequential modified Chang and Jackson P fractionation procedure. The extractants were 1.0 M NH_4Cl, 0.1 M NH_4F (8.5 pH), 0.1 M NaOH, and 0.5 M H_2SO_4. NH_4Cl extracted loosely bound forms of P, NH_4F extracted Al bound P, NaOH extracted mainly Fe bound and occluded Fe at 2 different steps separately and H_2SO_4 extracted Ca bound P. As the final step, non-extractable P (Residual) was recovered by 0.5 M H_2SO_4 after oven-dried at 70˚C and combusted at 550˚C. Inorganic P in the extractants was measured by ascorbic acid method using UV-Visible spectrophotometer. Total inorganic P accumulation of soil P in cultivated fields was significantly higher (264 ppm) compared to that in uncultivated fields (130 ppm). The fraction of NH_4Cl extractable P, which was readily available to plants were low in both fields (< 13% of total P). A large P stock (> 80 % of total P) was present in different P forms in soils, as Residual P, Al bound P, Ca bound P, and Fe bound P, which cannot be accessed by plants. Management practices should be modified to make these fractions available to plants. Soil P is continuously subjected to fixation by soil minerals. Phosphorus fertilizer management practices should be implemented in order to reduce P fixation.

Keywords: Fixed Phosphorus, Inorganic Phosphorus fractions, Long-term cultivated fields, Uncultivated fields

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* nandasenakalahe@gmail.com

Impact of Perceived Social Identity on Collective Efficacy Beliefs: An Insight from the Mahakanumulla Tank Cascade System

Rathnayaka R.M.M.P. and Anuradha J.M.P.N.*
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study investigated the beliefs of farm households receiving environmental services from the Mahakanumulla Tank Cascade System (MTCS) in Anuradhapura District regarding their efficacy to collectively manage the commons of the MTCS, and how those efficacy beliefs are structured by their perceived social identities. First, following a psychometric research paradigm, the study attempted to design measurement scales to gauge collective efficacy beliefs and perceived social identity of the individuals in the study population. Second, the study attempted to investigate how collective efficacy beliefs and perceived social identity of the MTCS inhabitants vary with their demographic characteristics. Finally, the study attempted to analyze how perceived social identity predicts collective efficacy beliefs. Data were obtained from a cross-sectional survey of 463 randomly selected adult respondents representing different households in 13 selected village communities of the MTCS. Structural equation modelling was employed to evaluate the validity of the measurement model and to estimate the structural model theorizing the causal relationship between perceived social identity and collective efficacy beliefs. The results confirmed the validity of the model in which collective efficacy beliefs had three dimensions; (1) Self efficacy towards collective action, (2) group's efficacy to organize itself for collective action, and (3) efficacy of the collective action in achieving collective goals. As depicted in the validated measurement model, perceived social identity had two dimensions; (1) consciousness of belonging to the group, and (2) affection generated by belonging to the group. Construct means of all the above 5 dimensions of the 2 scales were moderately high in the study population. Both collective efficacy beliefs and perceived social identity significantly ($P<0.05$) varied in terms of certain demographic characteristics of the population. With reference to the study population, this study revealed that perceived social identity significantly ($P<0.05$) predicts collective efficacy beliefs.

Keywords: Collective efficacy, Social identity, Management of the commons, Mahakanumulla tank cascade system, Structural equation modelling

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* anuradhaj@agri.pdn.ac.lk

Impact of Urban Development on Spatiotemporal Trends of Urban Heat Island of Three Cities of Central Hill, Sri Lanka and Potential Use of Lichens as Bio Indicators to Monitor Environmental Pollution

Welewanni W.W.M.S.M., Nissanka S.P.*, Gunawardena A.R.[1] and Weerakoon G.[2]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Major problems in unplanned urban development are the increase of urban heat island (UHI) effect and pollution level in cities. UHI is a phenomenon that shows a higher temperature in urban areas compared to surrounding rural areas. The purpose of this study was to examine the impact of urban development on UHI in three cities of central hill of Sri Lanka (Kandy, Badulla and Nuwara Eliya) during the period of 1996 to 2019 and to assess the diversity of lichens as a bioindicator to monitor air pollution in Kandy city. Accordingly, land use/land cover (LULC) classification was made by using a pixel based supervised classification method using Landsat satellite data and GIS techniques. The strength of LULC changes on land surface temperature (LST) was measured through relationships between LST and normalized difference vegetative index (NDVI) and normalized difference building index (NDBI). Increase of UHI was prominent in all cities. A negative correlation between LST and NDVI, and a positive correlation between LST and NDBI were observed ($p < 0.05$). Corticolous lichens were observed in *Mangifera indica* trees along three transects through the urban–rural gradient centering from Kandy city center. Due to the lack of diffusion information of air, distance from the city center considered as pollution–related factor. Shannon diversity index values of lichens showed a positive correlation with the distance from the city. Overall results revealed that UHI hotspots are prominent in core city areas where buildings are abundant and along road sides, and improving the green spaces can reduce UHI hotspots. The findings could be considered in future urban planning and landscape development in city planning. Moreover, lichens could be used as a potential bioindicator to predict environmental pollution.

Keywords: Bioindicators, Central hill, Lichen, LST, UHI

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[1]Central Environmental Authority, Battaramulla, Sri Lanka
[2]The Natural History Museum, United Kingdom
* spn@pdn.ac.lk

Influence of Study Habits on the Academic Achievement of Undergraduates of University of Peradeniya

Obesekara H.M.U.T. and Jayawardena L.N.A.C.*
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Academic achievement refers to the extent to which a person has achieved the specific goals within the education system. Study habits of undergraduates play an important role in their academic achievements. The overall objective of this study was to examine the influence of study habits on academic achievements of undergraduates of University of Peradeniya. Deductive approach was used with a quantitative methodology through a cross sectional survey. A two stage stratified random sampling method was used. The sample consisted of 428 third year undergraduates from four faculties of University of Peradeniya, viz; Faculty of Agriculture, Faculty of Arts, Faculty of Management, and Faculty of Science. The academic achievement of undergraduates was measured from their examination performances. In addition to study habits, nine independent variables were identified after an extensive literature review process. Primary data were collected using a self-administered questionnaire. Data were analysed using descriptive statistics such as mean, standard deviation, and frequency distributions. Inferential statistical analyses, such as independent sample t-test, ANOVA, and multiple regression tests, were conducted. Findings revealed differences of the study habits between males and females, and among the students of the four faculties of study. Examination performance had a positive relationship with the study habits of undergraduates ($p<0.05$). Further, examination performance had relationships with gender, English proficiency, engagement in extra-curricular activities, and father's education level ($p<0.05$). Academic life satisfaction had relationships with engagement in extra-curricular activities, type of accommodation, and father's education level.

Keywords: Study habits, Examination performance, Academic life satisfaction, Gender

* chandanacj@gmail.com

Information and Communication Needs of the Private Tea Leaf Collectors in Low Country Tea smallholdings, Sri Lanka

Kasthuriarachchi K.A.W.P.Y., Dissanayeke U.I.* and Munasinghe C.[1]
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tea leaf collectors play an important role in the tea supply chain by collecting fresh leaves from the growers, transporting leaves to factories and mediating financial transactions between the factory and tea growers. In Sri Lanka, there are two types of leaf collectors; factory line collectors and private tea leaf collectors. When compared with factory line collectors, private tea leaf collectors face many difficulties due to unavailability of information at the time of decision making. Detailed identification and mapping of such information and communication needs is useful in deriving technology-based solutions. Hence, this study was carried out to identify and prioritize specific information needs of the tea leaf collectors. A mixed method research approach was used. Data were collected using Participatory Rural Appraisals (PRA), key informant discussions and a questionnaire survey (n=72). Participants for the survey were selected using multi-stage sampling. The PRAs were conducted in Deniyaya (n=20) and Ingiriya (n=40). According to the findings, average monthly income of the respondents was 37,000 LKR while the majority (44%) has education up to GCE A/Ls. Mean age of the respondents was 48 years, while the mean years of experiences as leaf collectors was 13 years. On average, a private leaf collector supplied 13,500 Kilograms of tea leaves. The prioritized information needs were, price information (81.70%), information related to subsidy schemes (78.90%), weather information (71.83%) technical information (64.78%) and information on loan/ credit facilities (56.30%). In addition, the respondents were interested to receive information related to recommended quality standards, proper transporting methods and suitable packing materials. The study concluded that the leaf collector community is in need of up-to-date and effective information systems that can support decision making. Thus, it is necessary to develop such systems to cater to the information needs of the leaf collectors.

Keywords: Information needs, Communication needs, ICT tools, Technology, Tea Leaf Collector

[1]Deniyaya Extension Center, Tea Research Institute

* uvasarad@gmail.com

Intention of Tea Small Holder Farmers to Engage in Organic Tea Farming in Gurukele and Nillamba Areas

Kumara G.K.T.P. and Alahakoon P.C.B.*
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The majority of present generation of farmers do not seem to have a clear understanding about the concept of organic farming and its benefits. This study focused on investigating the intention of conventional tea farmers to convert into organic tea farming. In the Sri Lankan context it is important to understand why farmers make decisions in favour, or against, organic farming as well as to identify drivers and barriers affecting that decision. The Theory of Planned Behavior (TPB) explains how and why these social and interpersonal factors are connected. According to TPB, intention is a combination of attitude towards behavior, subjective norms and perceived behavioral control. In addition to these variables, other factors such as perceived usefulness of organic farming and personal characteristics of the farmer (age, income, number of family members, level of education and experience in tea farming) were added to the conceptual framework to investigate the influence on intention.This was a descriptive, quantitative, cross-sectional study. Participants were selected using a list-based sampling frame and the sample size was 59. An interview schedule was prepared to collect information from selected farmers. Multiple linear regression was performed to determine relationships among variables and Pearson correlation coefficient and Spearman correlation was calculated to measure the correlation between variables. Farmers in the sample group had scored significantly ($p<0.05$) lower than the average for both attitude and intention toward organic tea cultivation. Furthermore, all variables in the conceptual framework significantly correlated with each other ($p<0.05$). Age was the only demographic factor which influence to the intention. Nearly one fifth (20.8%) of the variance in the intention toward organic tea cultivation is explained by the factors included in the regression model. Participant's intention decreased 0.404 for each one Likert scale score of perceived behavioral control.

Keywords: Organic farming, Theory of Planned Behavior, Intention, Attitude, Subjective norms

* prasadb@agri.pdn.ac.lk

Investigation of Current Status of Dairy Production and Socio Economic Status of Dairy Farmers in Mullaitivu District

Deranzam B. and Dematawewa C.M.B.*
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

A study was conducted in Mullaitivu district to investigate the present status of dairy production, socio economic status of dairy farmers and constraints for dairy farming. The data were collected using a pre-tested structured questionnaire from 150 dairy farmers randomly and proportionately selected from six veterinary divisions. Average age of farmers was 47.55±1.05 years, 71.33% of those were males and 53.33% had received secondary education. Dairy farming was the main occupation for 41.33% of the farmers. Average land area was 0.46±0.08 hectares/farmer. Majority of farmers (95.33%) had owned homes and 75% had own wells as water source. Most of them (82%) practiced Hinduism. Extensive rearing system was practiced by 59.33% with 42.7% adopting semi intensive management. Farmers maintained unimproved cattle (49.3%), improved cattle (48.7%) or both, with 4.67% having buffaloes. Total milk yield was 4.48±0.26 liters/herd/day. Total herd yield varied significantly with the type of animals maintained ($P<0.05$). Buffalo herds had produced the highest total herd yields due to larger herd size. ANOVA procedure showed that improved animals produced significantly ($P<0.05$) longer lactations (8.16±0.1 months) compared with local cattle (4.92±0.1 months) and buffaloes (6.29±0.1 months). Gender and age of the farmer or their commitment (fulltime/part time) had no significant effect on milk yield ($P>0.05$). Friesian crossbred cattle recorded significantly ($P<0.05$) the highest yield (5.25±0.75 litres/day) and the other crossbreds showed intermediate levels of performance, while the local cattle and buffaloes produced the lowest (0.59±0.02 and 0.64±0.05 litres/day, respectively). Mean income from the farm and off farm were Rs. 8,339.83±539.92 and Rs. 11,038.93±951.46 per month, respectively. Main difficulties of farming were lack of capital (71.33%), regular grazing lands (54%), chilling facilities (31.33%), and good quality breeding material (20%). Better performance exhibited by some farms in some ranges revealed the potential and ways existing to improve all farms in general in Mullaitivu district.

Keywords: Dairy industry, Farming systems, Livestock, Northern Province, Management conditions

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* mdematawewa@gmail.com

Is *Panicum trichocladum* Invasive?

Saranasooriya M.S., Marambe B.* and Wijesundara D.S.A.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Panicum trichocladum is a grass, first reported in 2002 from Hanguranketha area in Sri Lanka. Invasiveness of *P. trichocladum*, which is listed as a potential invasive species, was assessed using the Post-entry Risk Assessment Protocol developed by the National Invasive Species Specialist Group (NISSG) of Ministry of Environment and Wildlife Resources. The assessment was done based on three criteria; (a) distribution of the plant species (12 queries), (b) impact of plant species on ecosystem (10 queries) and (c) invasive attributes of the species (16 queries), using secondary data and results of a field experiment that evaluated the impact of the weed (*P. trichocladum*) on *Zea mays* L. The field experiment was done in a RCBD with three replicates where the weed was planted at three densities; 25, 50 and 75 plants/12 m^2, having a weed-free control, with maize. Other weeds in the plots were removed weekly. Leaf area, plant height, plant dry weight of maize and the weed dry weight were taken at 60 days after planting (DAP). Cob length, number of kernel rows, seeds per cob, final grain yield of maize, and the weed dry weight were measured at 115 DAP. Pearson (parametric data) and Spearman's (non-parametric data) correlation coefficients were used to measure the strength of relationships between variables. Maize cob weight at 60 DAP and final grain yield decreased by 55% and 12%, respectively, at the highest weed dry weight compared to the control. High number of unknowns (6 out of 16 queries) was recorded under invasive attributes category in the protocol, with a total of 9 unanswered queries due to the absence of published data/information for all assessment categories. Results indicated that *P. trichocladum* will remain listed as a potential invasive alien plant in Sri Lanka, but requires re-assessment using more scientifically valid data/information.

Keywords: Invasiveness, *Panicum trichocladum*, Post-entry risk assessment, Weed competition, *Zea mays* L.

[1]National Institute of Fundamental Studies, Kandy

* bmarambe@pdn.ac.lk

Mapping of Natural Vegetation Types in Puttalam District: A Pilot Study

Bandara R.M.A.D., Premakantha K.T.[1] **and Pushapakumara D.K.N.G.***
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Sri Lanka has an exceptional variation in natural vegetation because of its topographic variation, spatial distribution and diversity of soils, climatic heterogeneity and being an island nation. Accurate vegetation maps will help and guide scientists, land managers, land developers and the public better understand the location and condition of each vegetation type. The overall objective of this study was to identify appropriate mapping method for island-wide natural vegetation mapping by conducting Puttalam district as a pilot study. Two Sentinel 2b satellite images were used to identify 300 locations via the unsupervised classification from 20 different land classes based on the proportion of land area. From classification guideline, ground truthing was done for those sample locations. From reclassification procedure 20 land classes were converted to 9. From that, 5 land types were identified as natural vegetation. After on-screen digitizing another natural vegetation was identified. Those vegetation types are, open Dry Zone forests, dense Dry Zone forests, shrubs, sand dunes, grassland and marshes and mangroves. Dense forest of 27,092 ha (17.13%) and open forest of 51,060 ha (32.28%) was in the study area. The least natural vegetation types are sand dunes 1,512 ha (0.96%) and mangroves 1,831 ha (1.16%). Grasslands and marshes cover 3,612 ha (2.28%) and shrubs cover 14,332 ha (9.06%) from the total 158,153.2 ha in the study area. Overall, accuracy of upper image was 82.5%, and lower image was 84.4%, which were higher than 80% of minimum accuracy standard. This pilot project helps the Forest Department to develop suitable procedures for producing island-wide natural vegetation maps.

Keywords: natural vegetation map, on-screen digitizing, reclassification, unsupervised classification

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[1]Conservator of Forest , Geo-information & Forest inventory, Forest Department , Rajamalwatta road, Battaramulla

* ngpkumara@pdn.ac.lk

Mapping the Consumption of High Quality Protein of Muslim Community in Udunuwara Divisional Secretariat Division using GIS

Husni R.M., Jayanath N.Y.* and Kumarihamy R.M.K.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study aimed at identifying the spatial variances of high quality protein consumption of the Muslim community in Udunuwara Divisional Secretariat (DS) division. A survey was conducted by visiting the selected 500 households covering all *Grama Niladhari* Divisions (GNDs) where the Muslim community lives. An interviewer-administered questionnaire was used for collecting data. Food items of high quality protein were selected for the study considering the net protein utilization (NPU) values of them. High quality protein intake percentage (HQPIP) of a household was determined by comparing the actual intake of the household with a safe level of intake of protein per day. Per capita availability per week (PCAW) of a certain food in a household was calculated by dividing the edible buying quantity of the respective food from the number of members of the household. The average HQPIP and average PCAW were calculated for each GND. Line densities of the road network of GNDs were determined. The spatial variance of average HQPIP and average PCAW of selected high quality protein foods for the selected GN divisions were analysed using ArcGIS software. Muslim community of Udunuwara DS division was spread in 71 GN divisions, approximately with 7000 households in the DS division. Average HQPIPs were comparatively high (75-100%) in Daskara, Ketakumbura, Gelioya, and Penideniya GN divisions and lower (below 25%) in Mampitiya, Werellamana, Dodamdeniya, Maveekumbura North, and Manikkawa GN divisions. A spatial difference in average PCAW was observed for all the considered food items. It was observed that the average PCAWs of certain food items influenced the average HQPIPs. A positive relationship between line densities of Udunuwara road network and average HQPIPs was observed.

Keywords: GIS, High quality protein intake percentage (HQPIP), Line densities, Per capita availability per week (PCAW), Spatial variation

[1]Department of Geography, Faculty of Arts, University of Peradeniya, Peradeniya, Sri Lanka

* jayanath11@gmail.com

Morphological and Molecular Characterization of Common *Loranthus* spp. (*Pilila*) in Sri Lanka

Jeewanthi P.B.D., Jayawardana N.U.* and Bandaranayaka P.C.G.[1]
Department of Agricultural Biology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Loranthus spp. commonly known as showy mistletoes (*Pilila*) are one of the most devastating stem-hemi parasites causing huge economic losses worldwide and of medicinal importance in indigenous medicine. There is limited literature on species identification and diversity of genus *Loranthus* in general and no records on phylogenetic positions and the diversity of *Loranthus* germplasm in Sri Lanka. Such information is vital in developing an effective control strategy and also in the authentication of the species. Therefore, present study aimed to identify common *Loranthus* species and within species diversity in Sri Lanka using both morphological and molecular traits. We assessed 7 accessions collected from different agro-ecological zones using 33 qualitative and quantitative traits. Traits such as growth habit, leaf arrangement, texture of upper leaf surface, shape of leaf blade, apex and base, colour of leaves, shape of corolla tube, shape of the pod, inflorescence type and colour contributed significantly to the morphological variation and grouped accessions into 4 clusters. However, the phylogeny of the species could not be resolved with the morphological data. Therefore, we PCR amplified and sequenced the 3 universally accepted cpDNA barcoding regions, *matK*, *rbcL* and *trnH-psbA*, to resolve the phylogeny. The standard molecular phylogeny analysis suggested the presence of at least 4 *Loranthus* species in Sri Lanka. 4 accessions having more or less similar morphological traits except the flower colour but confirmed as same species in DNA barcoding, were further assessed with three inter-simple sequence repeat markers (ISSR). Interestingly, the 4 accessions were genetically different from each other, suggesting within species genetic diversity. Current findings aid proper identification of *Loranthus* species in Sri Lanka that will lay the foundation for effective control strategies of parasitic plant and authentication and conservation of *Loranthus* for its medicinal properties.

Keywords: *Loranthus* spp., Morphological traits, DNA barcoding, ISSR analysis

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[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* nuj@pdn.ac.lk

Oil Spill Cleaning in Marine and Freshwater Environments: Application of Expanded Graphite (EG) and Reduced Graphene Oxide (r GO)

Witharana W.K.C., Madhubhashini E.T.S.*, Gunawardana M.[1], Kumara P.B.T.P.[2] and Ranasinghe T.S.[2]
Department of Animal Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Marine oil pollution is a serious threat to marine life. Oil blocks the interaction between the atmosphere and the water surface. Sorbents play an important role in oil spill cleaning operations. Most countries tend to use commercial synthetic polypropylene sorbents that have several negative effects on oil cleanups. The objective of the current study was to compare the effectiveness and efficiency of the commercial sorbents used currently in Sri Lanka with two newly identified local materials; Expanded Graphite (EG) and Reduced Graphene Oxide (r GO). Performances of various sorbents were analyzed with respect to the differences of variation in light intensity at the bottom with a light source and dissolved oxygen (DO) levels in both seawater and freshwater tanks. Burnt marine engine oil and crude oil were used as representatives of petroleum leakages. The results were analyzed in a completely randomized design for all four systems and it revealed that there are significant differences between the performance of the currently used and novel sorbents ($P<0.05$). EG resulted in a 4 times better ($P<0.05$) light intensity recover speed, higher mean and minimum DO levels in the system with heavy engine oil than the commercial sorbents. R GO performed 3 times better ($P<0.05$) with light crude oil than commercial sorbents. There is a good possibility to use these two new carbonaceous sorbents in oil cleaning operations effectively and efficiently since they perform better than currently used commercial sorbents.

Keywords: Sorbents, Oil Spills, Polypropylene, Expanded Graphite, reduced Graphene Oxide

This study was funded by Sri Lanka Institute of Nano Technology (SLINTEC) and it is acknowledged

[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama
[2]Marine Environment Protection Authority, Colombo

* thushanis@pdn.ac.lk

Performance Evaluation of an Up-Flow Anaerobic Sludge Blanket Reactor with a Bio-Filter Liner System

Narththanah S, Basnayake B.F.A.*, Ariyawansha R.T.K.[1] and Karunarathna A.K.
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The Up-flow Anaerobic Sludge Blanket Reactor (UASBR) is widely used due to its high potential in converting the food waste to bio-gas. Long start-up periods and inhibitions due to high ion concentrations are common issues of UASBRs. Therefore, a prototype UASBR was designed and developed by incorporating biofilter liner system to address these issues. This study was conducted for 40 days to evaluate the performance of UASBR with the modifications in the feeding system, recirculation system, and newly established sludge removal port. Food waste was prepared with the proper elemental composition based on the calculations done by solving the Linear Programming Problem (LPP). Initially, 24 kg of food waste mixed with 90 L of river water was fed from the bottom of the reactor. Reactor performance was evaluated daily by analysing the physical and bio-chemical parameters. Interventions such as addition of 1 M KOH, inoculum and food waste, recirculation, and sludge removal were done to enhance the anaerobic digestion and to accelerate the start-up process. All the parameters fluctuated responding to the interventions. Even though, pH was low inside the reactor, the methane gas production showed steady increase because methanogenic bacteria have started to adapt and acclimatize in the low pH environment. Mean gas production per day was 5.64 ± 6.38 L. Permeability of the composite liner system fluctuated between 2.0 $x10^{-6}$ and 5.2 x 10^{-6} cm/s which was slightly higher than the desired range for the landfills but these values are desirable for the UASBR. The colour of permeate was also a colourless solution. Also, towards the end of test period, total nitrogen, nitrate-nitrogen, available phosphorous, and total potassium were detected in permeate. Thus, the composite liner system acts as a live biofilter providing optimum conditions in the anaerobic digestion process via reducing the inhibitions and accelerating the start-up process.

Keywords: Bio-filter liner system, Bio gas, Food waste, Sludge blanket, Up-flow anaerobic reactor

[1]Solid Waste Management Research Unit, Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya

* benb@pdn.ac.lk

Photocatalytic Degradation of Bisphenol-A and Ciprofloxacin in Drinking Water Using Graphene Based Photocatalyst

Thennakoon T.A.K.A., Mendis B.E.P.*, Gunawardana M.[1] and De Silva R.T.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The toxicity of micro pollutants, bisphenol-A (BPA) and ciprofloxacin antibiotic present in drinking water, is a global food safety issue. This study was carried out to identify an effective method to degrade BPA and ciprofloxacin antibiotic, by using a newly developed graphene-based photocatalyst. Photocatalytic material was added to BPA or ciprofloxacin solution, stirred to ensure even dispersion of material and the unit was exposed to the light source. Degradation of BPA and ciprofloxacin were analysed with irradiation time using UV-VIS-NIR Spectrophotometer. A simple kinetic study was done using pseudo 1st order kinetic model and Langmuir-Hinshelwood model to study the relationship between degradation and irradiation time. Degradation behaviour was studied by changing pH, initial concentration of BPA and ciprofloxacin, photocatalyst concentration and light source. Highest degradation efficiency for BPA was achieved with 2.0 g/L catalyst concentration (95.5±0.20), 10 mg/L initial BPA concentration (95.70±0.73), pH 8.2 (92.60±2.85) and under visible light sources (95.7±0.73). Ciprofloxacin degradation was effective at 1.0 g/L catalyst concentration (98.13±0.12), with halogen light (97.56±0.12), and sunlight (96.38±0.19). Degradation of BPA with time showed a linear relationship under UV light and pH conditions 5.4, 7.3, and 8.2 giving squared correlation as 0.9523, 0.9797, 0.9515, and 0.9358 respectively. However, ciprofloxacin degradation did not exhibit a linear relationship with time. It was clear that degradation of BPA does not follow 1 st order kinetics when resulting in the higher degradation efficiencies. Further, degradation of ciprofloxacin does not follow 1st order kinetics at any identified condition. From the results, it can be concluded that graphene based photocatalyst developed in this study is a possible nano compound to degrade harmful BPA and ciprofloxacin present in drinking water sources. Material characterization is suggested to study the behaviour of the material during the degradation process.

Keywords: Bisphenol-A (BPA), Ciprofloxacin, Drinking water, Graphene-based photocatalyst, Light degradation

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[1]Sri Lanka Institute of Nanotechnology (SLINTEC), Pitipana, Thalagala Road, Homagama

* ereshamendis@agri.pdn.ac.lk

Phytoremediation of Wastewater Released by Coir Pith Processing Industry for Nitrate

Munasinghe M.M.S.M., Rajapaksha R.M.C.P.* and Gunasena A.[1]
Department of Soil Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Quality parameters of the wastewater released by the coir pith processing industry were tested to identify the effectiveness of the major stages of the wastewater treatment process by measuring pH, electrical conductivity, dissolved oxygen, total dissolved solids, NO_3^-, NH_4^+, PO_4^{3-}, K^+, Ca^{2+} and Zn^{2+}. Seven terrestrial plants, three aquatic plants and a wetland plant were tested to identify the phytoremediation potential for NO_3^- and K^+ in the wastewater released by coir pith processing industry. Plants were grown hydroponically in plastic pots with 1 L of tannin removed wastewater with the initial 77 mg/L of NO_3^- and 618 mg/L of K^+ concentrations. Experimental design was Complete Randomized Design with three replicates. Root volume and fresh weight of each plant; and NO_3^- and K^+ concentrations of each wastewater sample were measured initially and after 12 days. The highest average removal of NO_3^- on root volume basis was reported for *Ipomoea aquatica* (6.50 mg/cm^3) and followed by *Madhuca longifolia* (5.60 mg/cm^3); and on fresh weight basis for *I. aquatica* (4.44 mg/g) followed by *M. longifolia* (2.91 mg/g) and *Terminalia arjuna* (1.71 mg/g). Average removal of K^+ by *T. arjuna* is exceptionally higher in both per unit root volume (32.64 mg/cm^3) and per unit fresh weight basis (13.59 mg/g), followed by *I. aquatica* (9.53 mg/g) and *M. longifolia* (9.40 mg/g). *Canna indica, C. iridipola, Pandanus kaida* also have the potential to remove NO^- and K^+ from the wastewater. Strong positive correlations were identified among the NO_3^- and K^+ removal by all plants ($r=0.87$, $P<0.01$). Therefore, these plant species were identified as suitable candidates to construct a wetland that receive and purify wastewater released by coir pith processing industry.

Keywords: Coir industrial wastewater, Nitrate, Phytoremediation, Potassium

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[1]Jiffy Products S.L. (Pvt.) Ltd., Kobeigane, Sri Lanka

* chandir@pdn.ac.lk

Post-Consumer Plastic, Polythene Material Flow Analysis for Katunayake and Biyagama Industrial Zones

Silva K.S.M.D., Alahakoon A.M.Y.W.[1] **and Karunarathna A.K.***
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The recycling of plastic and polythene has been recognized as a solution to minimize the accumulation of plastic waste at the end disposal points. In waste management planning, especially the resources recovery and recycling processes are greatly depended on the quantitative assessment of material flow dynamics in a system. This study attempts to use the numerical modeling software STAN® for quantitative analysis of plastic waste flow in Katunayake and Biyagama industrial zone of Sri Lanka. Five major processes of material flow analysis (MFA); consumption, collection, processing, manufacturing, and dumpsite were identified in Katunayake Industrial Zone (KIZ) and Biyagama Industrial Zone (BIZ). All five major processes were available in KIZ and BIZ. It estimated the total waste generation in KIZ for the year 2018 was 700 MT per month. Fabric 55%, paper, and carton 25%, polythene and plastic 20% in KIZ. The overall recycling and reuse rate in KIZ is 50% from solid waste generation. Many polythene wastes go to recycling (10% from total waste generation) while many of the plastic wastes were chemical contaminated. But these hazardous plastics do not go through the recycling pathway in both industrial Zones. There were some main problems in both industrial zones such as inadequate knowledge on solid waste recovery, lack of good coordination among internal bodies, poor monitoring, insufficient technology, high transport cost, and poor coordination between factories and zonal environmental units. Some factories do not have proper waste storage facilities. Discarded, contaminated plastic and polythene should be sort and supply to recycle factories and developing proper coordination system will be helped to managed waste materials.

Keywords: Industrial zones, Material Flow Analysis (MFA), Plastic recycling, Plastic waste, STAN®

[1]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya

* anujica@yahoo.com

Quantitative and Qualitative Assessment of Food Waste Generation and Management at Source in Kandy Municipal Council Area

Chandrasena W.J.P., Rajapaksha T.N.[1] **and Karunarathna A.K.***
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Food waste has become an increasingly recognised environmental issue due to economic losses incurred and also due to environmental issues arise from inappropriate disposal of food waste. However, systematic studies on food waste generation, both in household and restaurant/hotel sector are very limited in Sri Lanka. Thus, this research was conducted to assess the food waste generation, handling and disposal practices by households and restaurants/hotels in Kandy Municipal Council (KMC). The assessment was conducted through questionnaire survey in 30 households representing low-income (< Rs. 10,000.00), middle-income (Rs. 10,000.00- 50,000.00), and high income (> Rs. 50,000.00) families in Mulgampola zone of KMC. Moreover, a quantitative measurements and food waste composition analysis were carried out for a week in by maintaining kitchen diary in households (*n=30*) and hotels/restaurants (*n=15*), and consequent weight measurements of food waste. The results revealed that the food waste generation in high-income families was 147 g/person/day which was significantly higher than low- and middle-income families (100g/person/day). In households, inedible food waste generate during food preparation was the main type of food waste while 50% food waste in hotel/restaurant sector occurs due to uneaten food serve to customers. At household level, 31-39% of food wastes due to preparation in excess the requirement. Sixty percent of food waste generates in high-income households either used for composting or backyard disposal while low- and middle-income families solely depend on KMC waste collection service. Resources recovery in hotel/restaurant sector was limited 7% of total food waste generation which is diverted to animal feed. The research highlights the need of intervention such as serving custom sized food portions to customs by restaurants/hotels and encouraging households to establish on-site resources recovery such as composting and biogas.

Keywords: Food waste, Household, Income level, Kandy municipal council, Restaurants

[1]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya

* anujica@yahoo.com

Recovering the Phosphate from Animal Farm Effluents through Phytoremediation: A Possible Source of Bio-Phosphorus Fertilizer

Nilooma G.H., Ariyaratne M. and Iqbal M.C.M.[1*]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Farm effluent is one of the substances which has the highest phosphorus (P) recovery potential. The aim of this study was, to assess the effectiveness of farm effluent treated *Salvinia molesta* as a P source using Mung bean (*Vigna radiata*) and Rice (*Oryza sativa*). After Salvinia was saturated (21 days) with phosphorus (1.26% P in dry matter basis), they were oven-dried and ground to prepare as a fertilizer. Rice and Mung bean plants were grown in pots filled with soil having a low content of P (2.91 mg P/kg of soil). These pots were exposed to 3 different P treatments; T1 (No TSP), T2 (Department of Agriculture (DoA) recommended P dose) and T3 (DoA recommended P dose was replaced with Salvinia powder). There was no difference observed between T2 and T3 with respect to shoot height, number of leaves, shoot P content, shoot dry weight and number of seeds per pod in mung bean ($P<0.05$). Number of pods per plant and grain yield per plant had increased in T2 than T3 by 1.9 fold. In rice, there was no difference between T2 and T3 respect to shoot height, P in shoots, number of seeds per plant and grain yield per plant ($P<0.05$). Results revealed that under saturated soil conditions Salvinia powder can effectively release phosphorus. These findings open up the possibility of utilizing farm effluent treated Salvinia in making organic fertilizer. Additionally, phosphate removal by *Salvinia molesta, Pistia stratiotes* and *Cyperus papyrus* from farm effluents (28 ppm) were studied for 14 days. P removal rate was 3.67, 1.81 and 1.13 mg of P from initial fresh weight, while tissue P content had increased by 10.8% 85.2% and 90.7% in Salvinia, Pistia and Cyperus respectively during the 14 days period.

Keywords: Eutrophication, Organic fertilizer, Phosphorus, Phytoremediation, *Salvinia molesta*

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[1] National Institute of Fundamental Studies, Kandy
* mcmif2003@yahoo.com

Resource Management of Tank Cascades: An Experiment of Farmer Investment Decisions on Public and Private Goods

Muzni A.M.A. and Prasada D.V.P.*
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Rural farming communities depend on Public goods for their farming activities in most part of Sri Lanka. Most of these public goods are natural resources. Continuous utilization of these resources leads to resource depletion and degradation. Investments on these resources will preserve these resources. Farming community is partially responsible for the investment on these public goods. Each farmer under the farming community has the option to contribute on these public goods. So each farmer has to make decision on the trade-off between public and private goods using private and public money. Two types of analysis were conducted and within each analysis two models were tested. Four hundred and eighty observations were made from 120 farmers of the cascade systems. Data were collected using experiment and structured questionnaire. Using the models Demographic factors, farmer related variables and choices made by farmers were tested with the choices made by the farmers through the experiment. For estimating models, logistic regression was used. The results of the study revealed that there is an impact by the farmer specific variables on investments on natural resources such as Trust induces private investments on natural resources and investment on the benefit of others while the farmers who prefer present than future are much interested in investments on self-benefit. Ultimately study founds farmers give priority to private goods, if the money used to contribute is private and farmers give priority to public goods, if the money used to contribute is public.

Keywords: Public goods, Investments, Private goods, Tank cascades, Agriculture

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* pahan1@gmail.com

Screening Different Climate Control Intensities for Greenhouse Tomato Production

Hettiarachchi M.H.S.M., Weerakkody W.A.P.* and Bandaranayaka P.C.G.[1]
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Agricultural production of Sri Lanka with respect to conventional farming has reached to a plateau where the country is unable to improve the agricultural productivity to meet the food needs of the growing population. Protected agriculture is a promising technological strategy to this rising problem. The tropical climate and the effects of global warming cause to accumulate heat inside greenhouses in Sri Lanka hindering plant growth, development and thus the productivity of greenhouse (high-value) crops. The technological solutions that are used by Sri Lankan greenhouse farmers to address this problem are variable and most inadequate. Therefore, this experiment was carried out to investigate the applicability of different climate control solutions (CCS) for greenhouse tomato cultivation under different intensities of environment control. The internal (micro) climate, crop growth (tomato) and yield of intensive CCS (T1; a semi-automated greenhouse with a double-cladded roof, insect proof roll-open side vents, high capacity blower along with a misting system), semi-intensive CCS (T2; a greenhouse with wind turbine ventilators, exhaust fans along with a misting system) and less-intensive CCS (T3; a greenhouse with an insect proof net covered continuous top vent) were compared with each other and also with open-field (T4; control) cultivation in this study. The three different CCS and the open-field treatment were cultivated with greenhouse tomato (*Solanum lycopersicum* L.) and their growth and development were compared against air temperatures and relative humidity. According to the results, T1 assured a favourable internal environment maintaining < 33 °C internal air temperature and > 55% relative humidity during day time with a better crop yield. And also, T1 appeared to be a potential solution for labour scarcity in protected agriculture as well as a quicker system response needed for sudden environmental changes.

Keywords: Climate control solutions, greenhouse temperature control, protected agriculture

[1]Agricultural Biotechnology Centre, Faculty of Agriculture, University of Peradeniya, Peradeniya

* palithaw@pdn.ac.lk

Social Entrepreneurial Orientation of Non-Governmental Nonprofit Organizations: A study in Ampara district of Sri Lanka

Shafna A. M., Kodithuwakku K.A.S.S.* and Kumar S.
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Social entrepreneurship has gained much attention in the recent past with the recognition of its importance to a country's economic development. Social entrepreneurial orientation (SEO) represents the entrepreneurial behaviour of nonprofit organizations. Understanding the level of SEO across different types of nonprofit organizations (NPOs) will immensely be helpful to develop training programmes and to give more group oriented support for nonprofit organizations. Therefore, the main research objective was to identify the levels of overall SEO and its key SEO dimensions (social innovativeness, social proactiveness, social risk-taking, reciprocity and social passion) across different types of organizations (international non-governmental organizations (INGOs), local non-governmental organizations (LNGOs), community-based organizations (CBOs) and social service organizations (SSOs)). An additional objective was to determine the factors affecting SEO of NPOs. Data were collected using a structured questionnaire from a sample of 110 non-governmental NPOs in the Ampara district of Sri Lanka. Descriptive statistics, one-way ANOVA and regression methods were used to examine the objectives of the study. Findings revealed that the level of overall SEO and all SEO dimensions of organizations except social passion differ significantly ($p < 0.05$) by the type of organization. Organization size, organic organizational structure and strong-tie resource mobilization have a significant ($p < 0.05$) positive relationship with overall SEO. Organizations that receive government financial support have significant ($p < 0.05$) higher overall SEO compared to the organizations without government financial support. The overall SEO of an organization differs significantly ($p < 0.05$) by the race of the manager or owner of the organization. Organizations with Tamil managers/owners had the highest SEO ($p < 0.05$), and organizations with Muslim managers/owners have significantly ($p < 0.05$) higher SEO than those managed by Sinhala managers/owners.

Keywords: Social entrepreneurship, Social entrepreneurial orientation, Social entrepreneurial orientation dimensions, Nonprofit organizations

* sarathsk@agri.pdn.ac.lk

Social Networking Behaviour of Small and Medium Scale Business Operators belong to Different Ethnic Groups: A Study in Wellawatte, Colombo, Sri Lanka

Yogarajah C., Kodithuwakku K.A.S.S.* and Korale Gedera P.M.
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Small and medium scale enterprises (SMEs) use social network ties to overcome resources constraints. Literature suggests that the structure and characteristics of social network ties of ethnic business operators differ due to specific and unique needs and preferences of each ethnicity. Therefore, the objective of this research is to investigate the structure and pattern of social network ties of SME business operators of three different ethnic groups; Sinhalese, Tamils and Muslims, in a selected geographical location; Wellawatte. Data were collected using a structured questionnaire from a sample of 90 respondents comprising 30 from each ethnicity. Data were analyzed using descriptive statistics, Kruskal-Wallis test, and Dunn's test. The structure of the social network of a given SME operator was measured based on the diversity of ethnic ties, male and female ties, and family and non-family ties. Findings revealed that there are significant differences ($p<0.05$) in size of social network ties between Sinhala, Tamil and Muslim SME business operators to mobilize resources such as finances, physical resources, emotional support and business services. There is a significant difference ($p<0.05$) in the ethnic composition of ties, family and non-family ties between the three ethnic groups to mobilize resources such as finance, labour, physical resources, new ideas and subject specific knowledge, business services and emotional support. All respondents use a higher proportion of ties belong to their own ethnicity. There is a significant difference ($p<0.05$) in Female and Male ties among the three ethnic groups to mobilize resources such as finances, physical resources, emotional support and business services. Sinhala and Tamil SMEs showed higher proportion of out-group ties whereas Muslims have a higher proportion of in-group ties. Geographical distribution of social network ties of the three groups also showed statistically significant differences ($p<0.05$).

Keywords: Ethnic-entrepreneurship, SMEs, Social network ties, Networking behaviour, Resource mobilization

* sarathsk@agri.pdn.ac.lk

Study of Damana parkland vegetation associated with the Nellikele forest reserve in Ampara

Kumara M.P.S.P. and Hitinayake H.M.G.S.B.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Damana is a vegetation type dominated by grasses found in the low lying areas in the dry zone of Sri Lanka. It is also identified as a parkland due to the presence of scattered trees on the grassland. Damana parklands get flooded for a considerable time due to the monsoonal rain and become dry during the long drought period. Very few studies have been conducted to identify the structure and composition and conservation value of the Damana parklands.

The objective of this research was to study the vegetation of the Damana parkland found in the Nellikele forest reserve in Ampara in the Eastern province. Vegetation study was conducted using systematic sampling. Fifteen 50m x 20m plots were randomly located using Google maps and visiting the site. Fifteen 3x3m plots were randomly located in the large plots to evaluate composition and diversity of the grassland areas in the parkland. DBH and height of all tree individuals recorded in the plots were measured.

Relative Importance Values (RIV) were computed and used to interpret the dominance of different tree species. Shannon and Simpson's indexes was used to measure the diversity of the vegetation. Also Floristic Richness Index (FRI) was calculated to measure the botanical richness of the vegetation. About 37 plant species with wide range of values and uses were recorded in the study. Dominant tree species of this Damana parkland are, *Pterospermum suberifolium, Ziziphus mauritiana, Bauhinia racemosa, Phyllanthus emblica, Chloroxylon switenia,* and the dominant grass species are *Imperata cylindrica , Desmodium triflorum* and *Mimosa pudica.* Ground cover vegetation coverage is 72 ± 10 %.

Study clearly shows that Damana Parklands are consist of diverse species assemblage. It is aesthetically pleasing and one of most preferred feeding area and habitat for conducting the social life of elephant herds in the area.

Keywords: Damana parkaland, Nellikele forest reserve, species diversity and dominance

* gaminih@pdn.ac.lk

Study on Use of Images in Infographics for Students in Teldeniya Educational Zone

Narasinghe N.M.N.S., Wickramasuriya H.V.A.* and Alahakoon P.C.B.
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Infographics, which is information visualization using graphic design methods, allows graphics and text to be integrated together. The education sector uses these Infographics due to its ability to facilitate understanding and retention. Infographics are used in Sri Lankan school textbooks. However, there were no relevant studies on using infographics in this sector, related to types of images and combinations. Hence, the main objective of this study was to find the effect on learning for different types of images and text-image integrations. The factors investigated were types of image; photographs, icons, cartoons and control (no images), and text-image integration; repetition and complementary. The experiment was conducted using 7 in-tact classes, of 35 students each, in 1AB and 1C schools. A pretest-posttest quasi experimental design, with a control, was used for the treatment groups including Photographs-Repetition, Photographs-Complementary, Icon-Repetition, Icons-Complementary, Cartoons-Repetition, and Cartoons-Complementary. Two posttests were done to investigate the forgetting effect. Recall and comprehension were analyzed, through ANOVA and Bonferroni post-hoc tests, as the learning outcome of the experiment. A significant difference was seen between types of image in both posttests ($p<0.01$). The results of the study revealed that Icon images had higher learning in 1st posttest as well as 2nd posttest. The Complementary Text-Image Integration type showed significantly higher learning than the Repetition one ($p<0.01$). The combinations of different components showed significant differences in learning. It was concluded that Icons image type, and Complementary Text-Image Integration type, were more effective for learning from Infographics. Thus, whilst further studies are needed to validate these findings, tentatively it could be stated that for these students, and for these types of subjects, it seems that Icons are the better images that should be used. Further, it is recommended that when text is integrated with images, that complementary texts should be considered more favourably.

Keywords: Infographics, Icons, Cartoons, Photographs, Text-image integration

* heshan54@gmail.com

Technical Efficiency and Its Determinants: Paddy Farmers in Mahakanumulla Cascade System

Perera K.L.P.A. and Hemachandra S.D.S.*
Department of Agricultural Economics and Business Management,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Paddy farming is predominantly practiced in the Dry Zone of the country landscape of which is characterized by the traditional hydrological cascade systems. Land is a scarce resource for agriculture in Sri Lanka. It is important to achieve high efficiency in paddy farming to increase the paddy production. This study examines technical efficiency of paddy farmers in Mahakanumulla cascade system and its determinants. Technical efficiency of the farmers is estimated using both parametric and non-parametric frontier techniques: Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). According to the results, the average technical efficiency of paddy farmers in Mahakanumulla cascade system is 92.3% in SFA. DEA using input-orientation yields an average technical efficiency of 61.4% and 79.8%, respectively, for constant returns to scale (CRS) and variable returns to scale (VRS) assumptions. The scale efficiency is 80.8%. DEA using output orientation yields average technical efficiency of 61.4% and 68.5% for CRS and VRS assumptions. Scale efficiency is 89.3%. Plot size, age, experience, house hold size, dummy for full time farming and dummy variables for sole ownership, shared ownership, permits (rented land use as the base for tenure dummy variables); were used in the inefficient model for determinants of technical efficiency. The plot size, age, household size, dummy for full time farming are positively related to inefficiency. All the other determinants are negatively related to inefficiency. The plot size, experience and household size are significant ($p<0.05$) from all the determinants modelled in the inefficiency model. The results reveal that the productivity of paddy farmers in Mahakanumulla cascade system could be increased by increasing the technical efficiency of farmers.

Keywords: Technical efficiency, Stochastic frontier analysis, Data envelop analysis, Inefficiency determinants, Paddy

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* dilinisp@gmail.com

Test of Root Tensile Strength of Candidate Plant Species for Soil Bioengineering in Shallow Landslides

Gamage H.G.V.D., Karunarathna A.K.* and Gamagedara K.Y.B.[1]
Department of Agricultural Engineering,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Application of soil bioengineering measures to mitigate slow and shallow landslides is a novel engineering concept. It has benefits of low cost and eco-friendliness over traditional engineering solutions. Tensile strength of root is one of the very important mechanical traits of a plant root, which has to consider in the process of selecting a plant species for soil bioengineering. In this study, five different root samples strength properties were tested and recorded: *Macaranga peltata*, *Gliricidia sepium* and *Trema orientalis, Lantana camara*, *Annona cherimola* and *Flacourtia indica.* This includes native species, which has economic benefits, and NBRO recommended plant species for landslide prone areas in Sri Lanka. Plant roots were harvested and tested within 24 hours. 15 cm effective length was used as root length and different clamping mechanism were tested. Each plant root was subjected to the same tension using speed in the dynamometer. Test results of tensile strength (MPa) versus root mean diameter (mm) were analyzed using linear regression. Finally, power regression models were developed for each species. In the analysis, power regression analysis proved that the tensile strength versus root diameter showed a significant relationship only for the three species; *Flacourtia indica, Anona cherimola and Trema orientalis*. According to the test results *Annona cherimola and Trema orientalis* species showed a relationship of $Tr = 16.93d^{-0.28}$ and $Tr = 82.31d^{-0.77}$which is compatible with root power model which is already proved. Further, *Annona cherimola and Trema orientalis* had higher goodness of fit of 76.8% and 72.3% respectively. Even though *Flacourtia indica* showed a higher goodness of fit, the relationship between root diameter and tensile strength was positive. Test results of *Gliricidia sepium*, *Macaranga peltata and Lantana camara* were not given according the root power model.

Keywords: Bioengineering, Root testing, Tensile strength

[1]Postgraduate Institute of Science, University of Peradeniya, Peradeniya

* anujica@yahoo.com

The "*Owita*" Agro-Ecosystem: A Promising Land Management System for Sustainable Agriculture

Lansakara L.A.S.I., Ranil R.H.G.*, Chamara R.M.S.R., Fonseka R.M., Rankoth L.M. and Suriyagoda L.
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

The *Owita* agro-ecosystem is a unique peri-urban land use system with specific soil types and found between paddy fields and uplands of the Wet zone of Sri Lanka. Though this ecosystem has a high potential to develop as a sustainable agro-ecosystem, it remains neglected, lesser-known and underutilized. The main objective of this study was to evaluate the present status of *Owita* agro-ecosystem focusing on its agro-biodiversity, temporal and spatial arrangement of crops, socio-economic aspects and ecosystem services. Thirty-five *Owita* systems were identified and assessed in Kegalle (20), Kalutara (10) and Galle (5) Districts. Vegetation and socio-economic surveys were carried out and soil pH, EC, OC, OM, N, P and K levels were measured from 20 *Owita* units. From the current study, it was evident that, *Owita* system is a home to rich agricultural diversity. Results further revealed its contribution to sustainable utilization and conservation of crop genetic resources. Further, this study reported 115 plant species belonging to 49 families and 99 genera, of which, the family Fabaceae was the most dominant family with 11 species. *Cocus nucifera, Gliricidia sepium*, *Manihot esculenta, Musa paradisica* and *Areca catechu* were the commonly occurring species. Though the traditional *Owita* agro-ecosystem characteristically an annual cropping system, it was observed that it is gradually transforming to a perennial-based cropping system. Plant species showed clear stratification and they were vertically arranged in three layers. Though there was no significant difference in soil P and EC between three Districts, N, K, OC%, OM%, and pH values were significantly different ($P<0.05$). Apparently, the *Owita* system can be considered as a high potential and sustainable agro-ecosystem which provides multiple benefits to the subsistence farmer and contributes in maintaining the natural balance of the ecosystems in peri-urban environments.

Keywords: agro-biodiversity, composition, *Owita* agro-ecosystem, sustainability

* rhgranil@gmail.com

The Correlation among Anthropometric Measurements and Body Fat Content of Male Undergraduates in the University of Peradeniya

Aqeel M.A.A. and Wijesinghe D.G.N.G.*
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was conducted to find out the correlations among anthropometric indicators and the body fat content of the male undergraduate students in the University of Peradeniya. Further, the body fat content was compared between first year and final year students and among different ethnicities. The risk for non-communicable diseases (NCDs) was identified based on established anthropometric cut-off values. The study was planned with a sample size of 600 students comprising four batches (first year to fourth year), in the proportion of Sinhala:Tamil:Muslim, 17:2:1, but only 107 was studied due to unexpected closure of the university due to Covid 19 pandemic. Age, ethnicity, vegetarian/non-vegetarian food practice and having food/drink or physical activity within 2 hours were recorded, while the height, waist circumference (WC) and hip circumference (HC) were measured using standard equipment. Body weight, body fat %, BMI, muscle mass, bone mass and body water content were obtained by the Body Fat Analyzer, which was operated on Bioelectrical Impedance Analysis (BIA) principle. Data were analysed using SPSS V19 software. Among anthropometric indicators measured, WC had the best correlation (R^2=0.71) with the body fat % compared to BMI (R^2=0.67), waist-to-hip ratio (WHR, R^2=0.36) or waist-to-height ratio (WHtR, R^2=0.67). The NCD risk of students based on anthropometric indicators ranged from 0% (WC >102 cm) to 30% (BMI >23). The mean value of all the indicators was below the risk level of each indicator. There was a higher mean body fat content in the final year students (19.8%) compared to first year students (16.4%). There was no difference in the body fat content among ethnic groups or between students following vegetarian and non-vegetarian food practice. Since the above relationships were established based on 107 subjects, small sample size might have affected the final analysis.

Keywords: Body fat, Anthropometric indicators, Bioelectrical impedance analysis, University students

* wijeng@yahoo.com

The Effect of Feeding Practices on Growth of Infants and Young Children up to Two Years in the Gampaha District

Silva W.D.C.K., Wijesinghe D.G.N.G.*, Jayatissa R.[1] and Herath H.[1]
Department of Food Science & Technology,
Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was designed to determine the effect of feeding practices on the growth of 0-2 year old children in the Gampaha district. An observational study was conducted in randomly selected 6 Maternal and Child Health (MCH) clinics in Gampaha and Mahara Medical Officer of Health (MOH) areas. The sample consisted of 100 children under 2 years. The child's weight and height data were collected from Child Health and Development Record (CHDR) and information on feeding practices were collected from mothers by an interviewer-administered questionnaire using 24-hour recall. WHO recommended infant and young child feeding (IYCF) indicators and associated feeding practices were estimated and their association with the weight gain was examined. The breastfeeding was initiated within 1 hour after birth by 86% of mothers and the rest could not do so due to caesarean deliveries. Of infants under 6 months of age, 79.5% were exclusively breastfed and others have consumed water and/or milk formula. All the children above 6 months were continuously breastfed and from them, 93.4%, 98.4% and 91.8% had minimum dietary diversity, minimum meal frequency and minimum acceptable diet, respectively. The consumption of dairy products (47.5%) and eggs (31.1%) was low. Maternal education had a significant positive relationship on weight gain (p=0.02). Milk formula feeding under 6 months had a significant negative relationship on weight gain (OR=0.67, 95% CI=0.53-0.84). Minimum dietary diversity (OR=3.33, 95% CI=0.33-33.9), minimum meal frequency (OR=1.0, 95% CI=0.97-1.10), minimum acceptable diet (OR=1.61, 95% CI=0.25-10.39) and maternal employment (OR=1.76, 95% CI=0.68-4.58), all had a high likelihood of contributing to a higher weight gain of children. There was no significant relationship between feeding indicators and weight gain. In conclusion, though IYCF indicators were found to be satisfactory, exclusive breastfeeding and consumption of diverse foods should be further promoted.

Keywords: Infant and young child feeding, Breastfeeding, Complementary feeding , Weight gain

[1]Department of Nutrition, Medical Research Institute, Colombo 08

* wijeng@yahoo.com

The Role of User and Service Attributes on Adoption of Mobile Based Agriculture Advisory Services by the Low Country Tea Smallholders in Kalutara District

Kumari W.D.I.S., Anuradha J.M.P.N.* and Dissanayeke U.I.
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Although a number of mobile-based advisory services have emerged to deliver information to tea smallholders, still the adoption of such services by tea smallholders is at a low rate. This research is an attempt to uncover the user and service attributes underlying this slow rate of adoption by tea smallholders in Kalutara District. The study was conducted with reference to the "*Govi Mithuru"* advisory service. Primary data were collected from a sample of 190 tea smallholders selected through stratified random sampling. A binomial logistic regression was performed to ascertain the effects of user and service attributes on the likelihood that participants were active users. The logistic regression model was statistically significant, χ^2= 178.641, p<0.01. The results revealed that smallholders who had a higher level of education (above GCE O/L) had 13 times higher odds to be active users than the rest. Increasing income from tea, land extent, perceived relevance, content richness, and usefulness were associated with an increased likelihood of tea smallholders being active users. However, increasing age was associated with a reduction in the likelihood of tea smallholders being active users. Among the active users, another binomial logistic regression was performed to investigate the user and service attributes affecting the likelihood of respondents being loyal users who had significantly adopted and promoted the service. The logistic regression model was statistically significant, χ^2= 27.244, p<0.0005. Increasing age, experience, perceived content richness, and usefulness were associated with an increased likelihood of tea smallholders being loyal users. The study concluded that adoption of mobile based agriculture extension services by tea smallholders can be improved if the service attributes can be improved. Adoption rate can also be enhanced if the user categories with lesser likelihood to adopt the services can be identified and targeted in promotional activities.

Keywords: Mobile-based advisory services, Tea smallholder, User attributes, Service attributes, *Govi Mithuru* service

* anuradhaj@agri.pdn.ac.lk

The Role of Women in Home Gardening in Sri Lanka

Kularathna P.M., Wijerathna R.M.S.* and Liyanage I.M.K[1]
Department of Agricultural Extension,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Home gardening is an important agricultural system in Sri Lanka since it provides various socio-economic, health and environmental benefits. Most of the scientific literature on home gardens (HGs) in Sri Lanka is on the structure, functions and evaluation of the production concerning biophysical and ecological aspects. The studies on the role of women in home gardening are meager. Thus, the main purpose of this study was to assess the role of women in home gardening in Sri Lanka. A total of 90 HGs were selected from three main home gardening systems in Sri Lanka based on the stratified simple random sampling method. The study locations were Bowalawaththa (30 urban HGs), Giragama and Manikdiwela (30 Kandyan Forest HGs), and Mihinthale (30 dry zones HGs) agrarian service areas. The data were collected through face to face interviews using a structured interview schedule. According to the results, women showed higher participation in many HG tasks like planting, watering, harvesting and processing while men showed higher participation in input supply, pruning, marketing, and land preparation depicting the gendered relationship of the activities. However, the overall participation of women in home gardening is significantly higher than the men ($U=1480$, $P<0.05$). There was a positive significant relationship between women's perceived level of knowledge on home gardening and their participation ($r= 0.343$, $p<0.05$). A total of 155 food crop species were identified from HGs showing the contribution for food security. Integration of livestock to HGs was less prominent. The highest problem index (259) was recorded for wildlife issues. In conclusion, women play a significant role in managing HGs and in decision making related to HG management. Therefore, the measures to develop home gardening should be gender-sensitive while addressing the specific problems faced.

Keywords: Home gardening, Role of women, Food security, Sri Lanka

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[1]Department of Political Science, Faculty of Arts, University of Peradeniya

* madhaviwijerathna@yahoo.com

Variation of Fine Root Biomass in Sri Lankan Tropical Rainforests with Altitude

Gunasekara S.P., Sanjeewani H.K.N.[1], Samarasinghe D.P.[2], Madhumali R.M.C.[3], Suriyagoda L. and De Costa W.A.J.M.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Tropical rainforests (TRFs) act as a major carbon sink and contribute to regulating global climate. Fine roots (diameter ≤ 2 mm), which contribute significantly to water and nutrient absorption and carbon cycling, are highly-responsive to environmental changes. The objective of this study was to determine the variation of fine root biomass (FRB) and fine root length density (FRLD) in Sri Lankan TRFs across an altitudinal gradient (117 – 2132 m above sea level) and thereby to determine the climatic and soil factors influencing FRB and FRLD. Soil samples were collected from two depths (0-15 cm and 15-30 cm) in 1 ha permanent sampling plots (PSPs) established in TRFs at Kanneliya (2 PSPs), Sinharaja-Enasalwatte (2 PSPs), Rilagala, Hakgala, Pidurutalagala and Horton Plains. Both FRB and FRLD showed highly-significant (p<0.0001) variation among locations at different altitudes and soil depths (p<0.001). Location × depth interaction was not significant. Both variables were greater at 0-15 cm depth than at 15-30 cm. Among locations, FRB increased from 3433 kg (dry basis) ha^{-1} at Kanneliya to 9307 $kg.ha^{-1}$ at Pidurutalagala while FRLD increased from 19.08×10^4 $m.m^3$ at Rilagala to 49.00×10^4 $m.m^{-3}$ at Pidurutalagala. Both FRB (p<0.0001) and FRLD (p<0.05) showed positive linear relationships with altitude with rates of increases being 2.166 ($kg.ha^{-1}$) m^{-1} and 44.1 ($m.m^{-3}$) m^{-1} respectively. Across locations and depths, FRB and FRLD were positively-correlated (r=0.725; p<0.0001; n=80). Fine root biomass was positively-correlated to soil total nitrogen (r=0.313; p<0.01), exchangeable potassium (r=0.239; p<0.05) and organic carbon (r=0.354; p<0.01), but was not correlated to soil available phosphorus and bulk density. Highly-significant (p<0.0001) negative correlations were observed between FRB and long-term mean annual temperature (r=-0.430), annual total rainfall (r=-0.375) and mean daily solar irradiance (r=-0.454). These results fill an important knowledge gap in estimating the carbon balance of TRFs in Sri Lanka.

Keywords: altitude, fine root biomass, fine root length density, soil nutrients, tropical rainforests

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[1]Faculty of Applied Sciences, University of Jaffna (Vavuniya Campus)
[2]Postgraduate Institute of Archaeology, University of Kelaniya, Sri Lanka
[3]Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

Variation of Wood Density in Different Tree Species Found in the Tropical Rainforests in Sri Lanka

Ranasinghe R.D.U.A., Sanjeewani H.K.N.[1], Wijetunga W.M.G.A.S.T.B.[2], Samarasinghe D.P.[3], Madhumali R.M.C.[4] and De Costa W.A.J.M.*
Department of Crop Science,
Faculty of Agriculture, University of Peradeniya, Peradeniya

Wood density (WD) is an essential parameter in estimating tree biomass using allometric equations. Absence of species-specific WD values is a major source of uncertainty in forest biomass estimation. This study was done to determine the inter-species variation and environmental factors determining WD of trees in tropical rainforests (TRFs) of Sri Lanka. Wood core samples were obtained from all enumerated tree species (≥10 cm DBH) in 1 ha permanent sampling plots of six TRFs (Kanneliya, Sinharaja-Enasalwatte, Rilagala, Hakgala, Pidurutalagala and Horton Plains) across an altitudinal range from 150 to 2132 m above sea level. A total of 389 trees belonging to 234 species, 117 genera and 58 families were sampled. When all data were pooled, WD ranged from 0.123 to 1.047 g/cm^{3}with a mean (±standard deviation) of 0.569 (±0.135) and a median of 0.563. Location mean WD varied within a narrow range (P=0.169) from Rilagala (0.536±0.099) to Hakgala (0.593±0.124). Wood density did not vary (P=0.328) with canopy position of a tree species in the forest's vertical stratification or the origin (endemicity) of the tree species (P=0.142). Highly-significant (P<0.0001) variations in WD were observed among species, genera and families. The interactions with location were not significant (P>0.05) for species and genera, but significant (P=0.029) for families. Mean WD did not show a significant (P=0.328) trend with altitude. However, the variability of WD, in terms its range and coefficient of variation, decreased linearly (P<0.05) with increasing altitude. Multiple regression analysis showed that rainfall had a negative effect on WD while solar irradiance had a positive effect. A similar analysis showed that soil organic carbon and total nitrogen had negative effects while soil available phosphorus and exchangeable potassium had positive effects on WD. Results of this work will increase the accuracy of biomass estimation of TRFs in Sri Lanka.

Keywords: Environmental factors, forest biomass estimation, inter- species variation, tropical rainforests, wood density

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[1]Faculty of Applied Sciences, University of Jaffna (Vavuniya Campus)
[2]Department of Biological Sciences, Factulty of Applied Sciences, Rajarata University of Sri Lanka, Mihinthale
[3]Postgraduate Institute of Archaeology, University of Kelaniya, Sri Lanka
[4]Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya
* janendrad@gmail.com

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