STUDY ON FLOWERING AND FRUITING PHENOLOGY, AND FLORAL BIOLOGY OF THE PARENTAL CULTIVARS OF TEA (*Camellia sinensis* L.) SEED GARDENS IN SRI LANKA

by

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ABSTRACT

Flowering and fruiting phenological and floral biological attributes of the parental cultivars in Tea (*Camellia sinensis* L.) seed gardens in Sri Lanka were assessed. Aiming to utilize the information to plan and implement the seed productivity enhancement programmes, in order to fulfill the increasing demand for the improved seed materials as an adaptation measure for climate change effects. The study was conducted in a representative sample of three isolated tea seed gardens located in the estates of Rambukkanda (Ratnapura), Salawa (Hanwella) and Reucastle (Dehiowita) in Sri Lanka.

Five major reproductive phenophases; Immature flower buds, Mature flower buds, Open flowers, Immature fruits and Mature fruits were assessed, using a pre-determined visual scale (0-5) monthly for a period of three consecutive years. Floral morphology, Pollen biology; Anther dehiscence, Pollen viability and Stigma receptivity were assessed in the floral biology study. Phenotypic diversity of the seed progenies were also assessed to estimate the approximate genetic diversity.

The study on flowering and fruiting phenology revealed the synchrony and the intensity of reproductive phenophases in relation to the time, parental cultivars and rainfall pattern of the locations. The major flowering peak of the year occurred from September to December with an additional brief peak in July. Major fruiting peak (cropping season) occurred from April to August. Significant ($P < 0.05$) variations in the intensity of flowering and fruit set was observed among the parental cultivars. The profuse flower setters (TRI 2016, TRI 2022, TRI 2025, TRI 3055, KEN 16/3 and S 106) and fruit setters (TRI 2016, TRI 2022, TRI 2025, KEN 16/3 and S 106) were identified accordingly. Phenograms and a phenological calendar were formulated subsequently to streamline the seed collection and to facilitate the garden management.

The taxonomical status reflected by the pistil related morphology could be compared with the phenological attributes of the parental cultivars. Whereas the cultivars closer to Assam types produce more seed yield than those closer to Cambod types, in an environment, where the Assam-Cambod hybrids are open pollinated to produce seeds. The longevity of the receptivity

period does not affect the effective pollination period, as the stigma was receptive even before the opening of the flower and continued till the flower withered off. Moreover, the profuse fruit setters possessed linear stigma with comparatively larger receptivity area, in contrast to the moderate and low fruit setters exhibiting apical type stigma with comparatively smaller receptive area.

Based on the outcome of the pollen biology and the phenotypic diversity assessments, pollen donor potential of the parental cultivars were determined. Cultivars with, High (TRI 2022, TRI 2025, TRI 3055); Moderate to high (TRI 2016, KEN 16/3, KP 204, S 106); Moderate (TRI 2027, TRI 3063) and low (TRI 3047) pollen donor potential were identified accordingly.

Seven parental cultivars (TRI 2016, TRI 2022, TRI 2025, TRI 3063, KEN 16/3, KP 204 and S 106) exhibited comparatively higher germinability levels, whereas the other two cultivars (TRI 2027 and TRI 3055) exhibited moderate germinability levels. TRI 3047 did not set fruits (seeds) at all.

Based on the overall results; four poly-clonal and six bi-clonal parental cultivar combinations, were identified for future gardens to ensure the enhanced seed production.

Poly-clonal combinations;

(1) TRI 2016, TRI 2022, TRI 2025, TRI 2027, TRI 3055, KEN 16/3 and KP 204

(2) TRI 2016, TRI 2022, TRI 2025, TRI 3055, TRI 3063, KEN 16/3 and S 106

(3) TRI 2016, TRI 2022, TRI 2025, TRI 3055, KEN 16/3, KP 204 and S 106

(4) TRI 2016, TRI 2022, TRI 2025, TRI 2027, TRI 3055, TRI 3063 and KEN 16/3.

Bi-clonal combinations;

(1) KEN 16/3 and TRI 2025 (2) TRI 2022 and TRI 3055

(3) S 106 and TRI 2022   (4) S 106 and TRI 2025

(5) TRI 2025 and KP 204   (6) TRI 2016 and TRI 3055

This is the first extensive report on flowering and fruiting phenology and floral biology of tea seed gardens both locally and internationally.

DESIGN, DEVELOPMENT AND EVALUATION OF A POWER WEEDER FOR ROW-PLANTED PADDY

By

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ABSTRACT

Rice is one of the major important crops which impacts the most people in the world especially in Eastern countries including Sri Lanka. Weed management is one of the major constraints in rice cultivation worldwide. Water management, biological strategies, manual, chemical and mechanical methods are commonly used weed controlling methods in rice cultivation. Most of weed controlling methods are not preferred by farmers due to higher water demand, low weeding efficiency, higher labour requirement, environmental and health issues. The mechanical method is the most preferable method despite absence of highly effective weeder for medium and large-scale cultivations. The effectiveness of existing power weeders is also low due to the associated rotary mechanism. Therefore, this research was aimed to introduce an appropriate lowland power weeder, especially for medium and large-scale rice farmers in Sri Lanka. The soil dynamics, crop and machinery interaction studies, comprehensive design calculations, fabrications, series of performance tests and modifications were carried out to achieve this goal. Newly designed Burial Type Lowland Power Weeder (BLPW) consists of power source, frame and separate mechanisms for power transmission, weed burying, turning/row changing, floating, manipulation and controlling which are facilitated to bare the activated load, burying the weeds, achieve the required tractive power, speed and machine control in road and field manipulation. In comparative performance evaluation, five weeding methods such as, Cono-weeder, modified "Asakura" wooden clog, rotary power weeder, newly designed BLPW and manual weeding (control) were evaluated. The newly designed BLPW showed, significantly higher field capacity (which is 8 times higher than the control), field efficiency and weeding efficiency. Further, it showed the lowest weed re-growth rate (23%) which is essential for sustainable weed control and moderately high-performance indexes. However, plant damage percentage, maximum tiller number and yield did

not show any significant variations ($p \leq 0.05$) among different weed control methods assessed. Further, the new BLPW showed moderately high break-even point of 0.88 ha yr^{-1}, suggesting that it is appropriate for the medium and large-scale farmers. The cost of operation and the labour requirement of newly designed BLPW were ¼th and □th from the conventional manual weeding, respectively. Moreover, this BLPW showed low fuel consumption and power requirement representing 48% and 42%, respective reductions over the power rotary weeder. Besides, newly designed BLPW showed higher satisfactory field performances in practical field tests; 0.03 ha h^{-1} effective field capacity, 83.25% field efficiency, 80% weeding efficiency, 6.34% damaged plants and 580 performance index, 22 maximum number of tillers and 6968 kg ha^{-1} rice yield. Further, calculated cost for weeding was Rs. 7671 ha^{-1} under the field test. Calculated fuel consumption, labour and power requirement were 0.503 L h^{-1}, 33 man-h ha^{-1} and 0.319 kW, respectively. Interestingly, no ergonomic or mechanical defects were reported during the field test and it was easy to operate. Based on the above results, newly designed BLPW can be recommended for medium and large-scale rice farming.

UTILIZATION OF INDUSTRIAL FRUIT WASTE: EXTRACTION, CHARACTERIZATION AND INCORPORATION OF PECTIN FOR VALUE ADDITION TO ICE CREAM

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ABSTRACT

Lime and mango are extensively used in Sri Lankan food processing industries and considerable volumes

of lime (65%) and mango (58%) wastes are thrown away. These waste possess significant quantities of

pectin and therefore appropriate methods to extract pectin from both peels can serve as the means of

valorization of fruit wastes and environmental protection leading to sustainable environment. Hence, the

present study aimed to establish the optimal pH, temperature and time to obtain maximum yield of pectin

from industrial lime and mango peel wastes using acid extraction method and the possibility to use them

as fat replacers in frozen dairy dessert (similar to ice cream).

Mango and lime peels obtained as wastes from fruit processing industries were dried at 60 ^{o}C, powdered

into particle size of 0.425 - 0.850 mm and stored in metalized polyester bags (Gauge no 06) at ambient

conditions for further use in the study. Proximate analysis was carried out for both peels to find out their

potential in food applications. The moisture contents of prepared lime and mango peel powders were less

than 10%. Both materials showed the higher carbohydrate (57.42% in lime peel powder and 64.19% in

mango peel powder), more than 18% of crude fibre and considerable crude oil (6.87% in lime peel and

4.43% in mango peel) contents, explicating that both peels can be used in foods as sources for

carbohydrate, fibre and oil. The study on physico-chemical and functional properties further showed that

both peels could be a good source for carbohydrates including pectin and had the maturity stages of as

good as that of resources being used for commercial pectin production.

Fifteen experimental runs with different combinations of pH (1.3, 2.5 and 3.7), temperature (60, 75 and

90 oC) and time (45, 90 and 135 min) were employed according to the Box- Behnken design in the

extraction of pectin. The yields of lime and mango peel pectins ranged from 8.1 to 21.9% and from 6.1 to 16.3% (dry basis) respectively. The empirical quadratic polynomial models developed for the effect of pH, temperature and time on yield and degree of esterification (DE) of both lime and mango peel pectins were significant (p<0.050) and fitted to all experimental data with high co-efficient determination (>95.00). Both models revealed that linear effects of pH, temperature and the interactive effects of pH, temperature and time showed significant impact (p<0.050) on the yield and DE of lime and mango peel pectins. Optimized conditions of pH 1.7, 81.2 oC and 126 min yielded the maximum of 23.23% pectin from lime peel whereas optimized pH 3.38, 90 oC for 135 min yielded the highest of 17.1% pectin from mango peel. Lime peel pectin extracted under optimized conditions showed 857.0 ± 24.0 equivalent value, 8.3 ± 0.4% methoxyl content, 70.0 ± 0.5% DE, 77.0 ± 2.1% anhydro uronic acid content and 190 gel grade. Mango peel pectin possessed 2622 ± 35 equivalent value, 9.2 ± 0.1% methoxyl content, 88.5

± 0.3% DE, 74.2 ± 0.9% anhydro uronic acid content and 190 gel grade. All these properties exerted that both lime and mango peel pectins were better than commercial pectin (INS 440i) and can be recommended for applications in food industry. The study further revealed that 69.51% fat in the commercial ice cream can be replaced with 0.3% pectin of either lime peel or mango peel pectin without causing any significant difference in its textural and melting properties and therefore, both lime and mango peel pectins can act as fat replacers in the water-oil- water emulsion well.

Evaluation and Comparison of the Nutritional Composition of Selected Traditional Cereals, Pulses and Yams Grown in Sri Lanka

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ABSTRACT

This study was conducted to determine the nutritional composition of selected locally available traditional cereals, yams and pulses grown in Sri Lanka. Further, it determines the nutritional composition of selected traditional cultivars/varieties with an emphasis on seasonal variation. A comprehensive compositional database of traditional and underutilized rice, cereals, pulses and yams is not available in Sri Lanka. Therefore, this study would be beneficial to obtain a general consciousness on the composition of traditional rice, cereals, pulses and yams available in Sri Lanka. Proximate composition, dietary fiber content, fatty acid profiles, mineral profiles and vitamin profiles of ten rice varieties, five cereal varieties, eight pulses varieties and four yam types were evaluated. Sample collection was done by collecting samples representing all agro-climatic zones of Sri Lanka. Pooled composite dried powders of selected varieties were used for analysis. Yams contained the highest available carbohydrates compared to all the samples tested. However, yams were low in crude protein, dietary fiber and crude fat. Pulses were rich in ash in addition to proteins. Millet varieties analyzed were richer in ash and dietary fiber compared to rice varieties tested in the current study. Available carbohydrates in tested rice varieties were higher than in millet varieties tested. Foxtail millet contained richer crude fat content and fatty acid profiles compared to all the other samples analyzed and pulses were the best source of dietary fiber out of all the varieties tested. All the samples analyzed were rich in potassium while heavy metal content of all the commodities were remained below the harmful level to the human health. Improved rice varieties possessed higher contents of calcium compared to traditional rice varieties, while traditional rice contained higher iron content compared. Finger millet varieties analyzed were rich sources of calcium and manganese while foxtail millet varieties were rich in copper and zinc. Pulses are rich in iron while *Angili ala* was found to be a good source of sodium. The most abundant fatty acid present in rice varieties was oleic acid, while foxtail millet varieties tested were richer in both saturated and unsaturated fatty acids. Palmitic acid and linoleic acid were the most abundant fatty acids found in yams. All the commodities analyzed

were rich sources of thiamin and riboflavin while fat soluble vitamin contents of tested varieties were very low compared to vitamin B_1 and B_2. Nutritional profiles of tested varieties proved that adding these verities to the daily diet can meet RDA values successfully. Rice varieties cultivated in *Yala* season (2016) showed significantly higher nutritional value (except water-soluble vitamins) than rice cultivated in *Maha* season (2015) probably due to higher rainfall received in *Yala* season, environmental and climatic conditions. Further repeat studies are required to decide whether *Yala* season results comparatively more nutrious rice than in *Maha* season. This study can be used as a preliminary trial to conduct a new study to discover whether the nutritional composition of rice is affected by the seasonal variation.

Keywords: Cereals, Evaluation, Nutritional composition, Pulses, Traditional, Yams

ENVIRONMENTAL AND LIVELIHOOD IMPACTS OF DEDURU OYA DAM CONSTRUCTION AND WATER DIVERSION

by

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ABSTRACT

Dam construction and water diversion have become a common feature of development in the world to receive multiple benefits. Yet the dams are criticized because of their negative impacts to the environment and to the society. Deduru Oya reservoir project in Sri Lanka is a large dam project commenced in 2014 with the objective of providing irrigation water to around 7000 ha of lands in Deduru Oya basin and around 4115 ha of lands in Mi Oya basin. The main objective of this study was to evaluate the social, livelihood and some environmental impacts of Deduru Oya dam construction.

The status of resettlement program adopted in Deduru Oya reservoir project was studied addressing the legal framework for resettlement in Sri Lanka using literature survey and short interviews with relevant officials in the land office of the Deduru Oya Reservoir project. Moragahakanda reservoir project was also executed in parallel to the execution of Deduru Oya reservoir project. Since both are large dam projects, resettlement action plan of Moragahakanda reservoir project and its legal background was used to compare with that of Deduru Oya reservoir project to identify positive and negative aspects in two projects. The land use/ land cover in Deduru Oya reservoir area before inundation and within a 100 m buffer zone around the reservoir was assessed to identify the changes and its livelihood and economic impacts. Satellite imagery available in Google Earth were visually interpreted and land use/ land cover maps were produced for the purpose. To evaluate the social and livelihood impacts on resettled communities of Deduru Oya project, primary data were collected from Key Informant Interviews (KII) with the government officials (Irrigation Directors" Office, Kurunegala and Grama Niladhari officers of each resettlement site) and with a questionnaire survey on resettled

communities (134 families from four resettlement sites). Secondary data sources include content analysis of documents on Deduru Oya reservoir project. Data were analysed to assess the social and livelihood impacts as the result of displacement. Livelihood vulnerability index was developed to compare the four resettlement sites. The stream flow changes in the downstream were analysed using flow data before and after dam construction at Rideebendi Ella anicut located 300 m downstream and with rainfall data from Batalagoda rain gauging station in the upstream. All the outputs were used to comment on the impact on Deduru Oya dam construction on the society and the environment.

According to the analysis, Deduru Oya reservoir project has received relatively less scores compared to Moragahakanda project in terms of payment of compensation, resettlement process, resettlement planning principles and land acquisition guidelines. This shows that implementation of resettlement related procedures in Deduru Oya reservoir project has not achieved the same levels as that of Moragahakanda project. The Livelihood Vulnerability Index (LVI) is a useful tool to analyse the impacts on livelihood in a community affected due to development projects and it covers seven major components of livelihood vulnerability and address almost all possible ways of distresses upon the resettled community. According to the LVI, Karuwalagaswewa resettlement site brings the best opportunities to the resettled community to restore their livelihoods as it obtained least LVI value. However, as this resettlement site is located far from the original places of people and remote, the satisfaction level of the people who lives in Karuwalagaswewa was found to be the lowest. Though the LVI has the highest value in Ganawaththa resettlement site mainly due to lack of agricultural lands, the overall satisfaction among the resettlers is the highest due to availability of infrastructure and

other facilities. According to the analysis, Deduru Oya reservoir has inundated about 1170 ha of total land extent which consists of 40% of paddy lands, 31% of coconut lands and 27% of forest lands. A total of 555.76 ha of paddy lands has submerged in the reservoir. The paddy yield loss was estimated as 2257.50 tons in 2014 *Maha* season due to the reservoir construction.

Downstream flow of Deduru Oya stream has been considerably affected due to the dam. However, the water availability is high after the dam construction due to flow regulation by the reservoir. This benefit mainly the farmers in the downstream irrigation schemes such as Magalla irrigation scheme since water supply during dry season has increased after the dam construction.

The study identified that the Deduru Oya dam construction has brought positive and negative impacts to the people and the environment. High spatial resolution satellite images available in Google Earth provided a better picture of the land use/ land cover changes in the area. Livelihood displacement followed by physical displacement of people and associated problems are evident in the study. Hence, further in depth studies on resettled communities and the downstream environment are needed to assess the long term recovery process and to bring support mechanisms to overcome the negative impacts.

MONITORING FLOATING AQUATIC PLANTS AND ALGAE DISTRIBUTION

AND ASSESSMENT OF BIOMASS IN BATTICALOA LAGOON USING

REMOTE SENSING & GIS

by

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ABSTRACT

Batticaloa lagoon, the third largest estuary in Sri Lanka is frequently affected by floating aquatic plants (FAPs) dominated by *Eichornia crassipes* and floating algae (FAg). This study was aimed at mapping the spatial and temporal distribution of FAPs and FAg in Batticaloa Lagoon using remote sensing and GIS and to explore the relationship with water quality and the LULC in lagoon surrounding. The primary objective was achieved via assessing temporal and seasonal distribution of FAPs and FAg along with LULC in the lagoon buffer zone (LBZ), developing relationships between field measured and satellite derived biomass to estimate the distribution of Green (GBM) and Dry (DBM) biomass of FAPs, detecting algal distribution using satellite image classification techniques, mapping the seasonal variability of selected water quality parameters and assessing the impact on the distribution of FAPs and FAg in both seasons and finally developing combined risk maps to identify the spreading of FAPs and FAg in relation to Water Quality Index (WQI) in Batticaloa lagoon.

The study used cloud free Landsat and Sentinel 2A (S2A) images to detect FAPs and FAg to assess the temporal (1988-2016) and seasonal changes (2017-2018) using unsupervised classification. A buffer zone of 3 km was created around the lagoon to obtain the LULC distribution in the LBZ to study their influence on fluctuation of FAPs and FAg. Real time field measurements of biomass of FAPs were obtained in 12 locations in two week intervals for the period of March 2017 to February 2018. A number of band ratios and indices were developed using Landsat 8 (L8) and S2A images to establish relationships with field measured biomass to develop biomass distribution maps of FAPs in both

seasons. Sub-pixel classification was used to identify the distribution of FAg based on the level of pixel reflection which indicated the algal coverage.

Selected water quality parameters were measured at 30 sampling locations in 200 m inner lagoon buffer zone (ILBZ) in monthly interval from March 2017 to February 2018 to coincide with satellite images acquisition (near real time) to interpolate the spatiotemporal distribution of water quality. The impact of water quality on field measured and estimated biomass of FAPs and coverage of FAg were assessed to develop WQI in order to map and identify the risk areas on spreading of FAPs and FAg in relation to WQI of Batticaloa lagoon.

The multi-temporal analysis revealed that the distribution of FAPs and FAg showed an increasing trend from (2.4 to 7.0 %) and (0.7 to 2.3 %), respectively from 1988 to 2016, while the extent of paddy lands and built ups were expanded and the vegetation and bare lands were declined in LBZ, simultaneously. Seasonal pattern of FAPs and FAg revealed that the distribution highly varies between dry and wet seasons. The LULC analysis in the LBZ revealed that paddy (53 %) is the abundant land use in the study area and the cultivation is highly seasonal followed by built ups (39 %). Both have high impact on the distribution of FAPs and FAg in both seasons.

Among 21 tested band ratios and indices, B3/B5 (Green/NIR) and B5/B4 (NIR/Red) of L8 images showed strong positive correlation with field measured GBM and DBM ($r^2 = 0.72$ and 0.61) in dry season and ($r^2 = 0.82$ and 0.69) in wet season, respectively. NDREI

of S2A showed strong positive correlation with field measured GBM and DBM ($r^2 =$ 0.78 and 0.71) in dry season and B8/B4 (NIR/Red) and NDREI_Narrow ($r^2 = 0.68$ and 0.61), respectively in wet season.

Seasonal variation of water quality of Batticaloa Lagoon depends on more than one physicochemical parameters of lagoon. Furthermore, filed measured and estimated biomass of FAPs and spatial coverage of FAg showed significant correlations ($p<0.05$, $p< 0.01$) with water quality of lagoon in both seasons. The developed WQI showed a strong inverse relationship with field measured GBM ($r^2 = 0.70$, 0.70) and DBM ($r^2 =$ 0.70, 0.77) of FAPs in both seasons and with the coverage of FAg ($r^2 = 0.78$) in dry season.

Biomass distribution maps of *Eichornia crassipes* relevant to WQI showed higher level of risk in Navithanveli and Kalmunai DS divisions, moderate level of risk in Manmunai South Eruvil Pattu and low level of risk in Manmunai Pattu and Manmunai Southwest Pattu DS divisions. High algal infestation (>70 %) was confined to Manmunai North, Eravur Town and Kathankudy DS divisions and moderate level of coverage (50-70 %) is at the locations confined to Eravur Pattu and Manmunai West DS divisions. LULC analysis showed that these locations are prone to urban and agricultural runoff discharges due to rapid urbanization and intensive agricultural activities. However, the sampling locations enriched with natural habitats were free from FAg.

The study shows that the Landsat and S2A images have the potential to detect and map the level of risk in the spreading of FAPs and FAg which can be linked to WQI-LULC dynamics in the lagoon buffer zone.

DEVELOPMENT OF A DIVERSITY AND BIONOMICS GUIDED MANAGEMENT SYSTEM FOR MELON FRUIT FLIES (DIPTERA: TEPHRITIDAE) IN SRI LANKA

by

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ABSTRACT

Pumpkin, bitter gourd, luffa, cucumber and snake gourd are some of the major cucurbits grown in Sri Lanka for local consumption and for export market. Several Melon Fruit Flies (MFF) are considered as the most destructive pest complex of these cucurbit crops. Therefore, this study was conducted to determine the abundance and diversity of MFF in three selected districts in Sri Lanka, namely Anuradhapura, Kurunegala and Kandy with a view of redesigning the management system recommended for MFF, considering the bionomics of the pest complex in agro ecosystems of the country.

Three species of cucurbit infesting MFF namely, *Bactrocera cucurbitae, B. tau* and *Dacus ciliatus* with abundance of >86%, 12% and <1% respectively have been recorded in Sri Lanka. *B. diversa* has been recorded only from the pumpkin flowers. Cue-Lure parapheromone traps placed in selected locations in the above districts attracted four species of MFF, namely *B. cucurbitae, B. tau, B. caudate* and *B. diversa* and six species of Fruit Flies, *B. trilineata, B. nigrotibialis*, *D. caillantra* and *B. gaviza, B. dorsalis* and *B. correcta*. Furthermore, the Methyl Eugenol pheromone traps placed in above locations, attracted *B. dorsalis*, *B. kandiensis, B. correcta, B. zonnata, B. versicolor* and melon fly *B. cucurbitae.* (However, one of the MFF, *D. ciliatus*, recorded in these locations did not attract to Cure Lure and Methyl Eugenol traps). The Parapheromone Cue-Lure mass trapping at the rate of 1 trap/ha (100 traps/km^2) as a management tool for MFF was deployed in three locations namely Pallekelle, Pitawala yaya and Horticultural Crop Research and Development Institutes field in Kandy district.
 After six months of continuous trapping, MFF counts were significantly lower (χ^2 29.97; P<.0001) compare to the initial counts in Pallekelle field.

The average temperature of 27 C^0, relative humidity 70-85% and the presence of photoperiod Light: Dark - 9: 15h, the whole life cycle of *B. cucurbitae* completed within 17-18 days. The whole life of cycle *B. tau* was 14-16 days. *B. cucurbitae* egg lays during the first week of its

emergence and the peak period was observed in third to fourth weeks with the higher amount of eggs. During the assessment average temperature and RH were 26.5^0C and 82%. *B. tau* egg lays during the second week of its emergence and the peak period was observed in five to sixth weeks.

The rate of parasitism of MFF observed in infested cucurbit fruits collected from Kandy, Anuradhapura and Kurunegala Districts was around 2% , <1% and 0% respectively. Cucurbit samples collected from farmer fields exposed to different insecticides were tested for residues of Acephate, Profenophos and Abamectin showed that some cucurbit samples contained residues of Acephate 75% SP and Acetamiprid 20% SP.

Number of MFF attracted to a blend of Cue Lure: Methyl Euginol (ME) (3:1) traps were significantly higher for *B. cucurbitae* (χ^2 84.2; P<.0001), *B.tau* (χ^2 43.1; P<.0001) and true fruit flies, *B. dorsalis, B. kandiensis* and *B. correcta* (χ^2 148.1; P<.0001). Hence, a mixture of CL: ME (3:1) can be used to attract more MFF for male annihilation programs.

Therefore, continous mass trapping MFF using Cue Lure: Methyl Euginol (3:1) blended parapheromone, removal and destroy of infested fruit through Augmentorium, covering of fruits in post set stage using breathable cloth material and application of protein bait for larger fields would help lower the MFF infestation (<5%).

Fumigation (using liquid phosphine (ECO$_2$FUME) -2% phosphine in 98% carbon dioxide w/w) at the rate of 1,400 ppm for 24h exposure found to be effective for post-harvest disinfestations of cucurbits from *B. cucurbitae* (eggs, young and old larvae stages) in export quality bitter gourd.

A BASELINE SURVEY OF CORAL REEFS AND GENETIC DIVERSITY ANALYSIS OF SELECTED CORAL SPECIES IN JAFFNA PENINSULA AND ITS' MAJOR ISLANDS, SRI LANKA

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ABSTRACT

Jaffna Peninsula, the most extensive lagoon system in Sri Lanka, features diverse marine habitats including mangroves, seagrass beds, salt marshes, sand dunes and coral reefs. It covers 182 mile coastal belt. Knowledge on status of coral reefs in Jaffna Peninsula is often limited, and genetic diversity studies of coral species never explored in Sri Lanka. Aim of this present study was to identify the diversity, distribution, and status of coral reefs underpinning the health of reef ecosystems. Baseline field surveys were conducted with point Line Intercept Transects (LIT) method to characterise the benthic features such as live hard coral (HC), soft coral (SC), nutrient indicator algae (NIA), recently killed coral (RKC), rocks covered with turf algae or coralline algae (RC), broken coral rubble (RB), sponges (SP), silt (SI), sand (SD) and others (OT). The percentage benthic categories were assessed based on the standard Reef Check methods at the islands of Karainagar, Delft, Punkudutivu, Mandaitivu, Kayts and the four northern coastal regions namely Point Pedro "Munai", Inbarsitty, Thondaimanaru and Valithoondal. The Northern coastal line of Jaffna Peninsula has the average live coral cover of 48.5%. Islands have an average of 27% live coral cover. There was a higher percentage of standing dead coral covers of branching *Acropora* and large domes of *Porites, Goniastrea* observed at the Allaipiddy site in Kayts, next to Punkudutivu island. Corals of the Kayts, Mandaitivu, Delft and Punkudutivu islands were severely affected since the dead coral cover was high.

Morphological identification of coral species was made based on the skeleton structures, corallite patterns, growth pattern of colonies and forms of corals. There were a total of 123 hard coral species and eight soft coral species identified throughout the survey sites in this study. They represent the 12 families and 43 genera. Among the morphologically identified

hard corals, 46 species were first time recorded in the Sri Lankan territory from this study. There were nine species found to be difficult to distinguish morphologically, applied for DNA barcoding by using the mitochondrial *cytochrome oxidase subunit I gene (COI)* for confirmation of species. Morphological identification through traditional taxonomy and DNA barcodes were consistent for all samples up to genus level. A common phylogenetic tree was constructed using the Neighbor Joining method to verify the species which are closely related and morphologically cryptic. The overall maximum nucleotide frequencies observed for the sequenced samples were G (24.50%), C (19.24%), A (21.60%) and T (41.92%). Nucleotide pair frequency analysis of ten coral samples revealed that 368 of 500 sites (73.6%) were conserved, 132 of 500 (26.4%) sites were variable, 79 of 500 (15.8%) sites were parsimony informative, and 53 singleton sites were present, confirming the usefulness of mtDNA in species-level phylogenies in corals. All the successfully sequenced species belong to genus *Acropora, Montipora, Pocillopora, Galaxea* and *Echinopora* were confirmed with the barcoding and phylogenetic results parallel to the morphological identification. Thus, present baseline survey results and genetic diversity analysis significantly extended the knowledge and understanding of untouched biodiversity of reef building Scleractinian corals which would support and develop conservation efforts to onslaught the declining biodiversity and threats of coral reef ecosystems in Jaffna Peninsula.

Key words: DNA barcoding, cryptic species, benthic coverage, phylogeny, coral degradation, turf algae.

MOLECULAR CHARACTERIZATION OF BEGOMOVIRUSES INFECTING

OKRA VARIETIES GROWN IN DIFFERENT LOCATIONS IN SRI LANKA

AND DEVELOPMENT OF EFFECTIVE AND ECO-FRIENDLY APPROACHES

FOR ITS' MANAGEMENT

by

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ABSTRACT

Okra (*Abelmoschus esculentus*) has been grown as a major vegetable crop in all agro-ecological zones of Sri Lanka either as a home garden crop or at commercial scale. At present, okra production in Sri Lanka has been severely affected by okra yellow vein mosaic disease (OYVMD). Reports based on symptomatology and preliminary molecular studies have identified the causal agent of OYVMD as a begomovirus. However, in depth investigations on identification and characterization of the causal agent and determination of effective management strategies are a timely need.

The major objectives of present study were to confirm the identity and characterize the causal agent/s of OYVMD at molecular level, to screen resistant varieties of okra available in Sri Lanka to OYVMD, to find out reliable methods to detect OYVMD in plant tissues at their early stages of infection, and to discover a set of non-chemical pesticidal and eco-friendly approaches to manage the disease.

In order to confirm the identity and to get an insight of the molecular variability of causative agent/ agents, symptomatic leaf samples were collected from six different locations in Sri Lanka and total genomic DNA were isolated using a modified method developed in the present study.

The extracted DNA was amplified using primers specific to begomovirus and betasatellite. The full-length genome of the DNA-A was PCR amplified and the amplicons of DNA-A from two samples representing each location were cloned, sequenced, and deposited in GenBank database. Based on the sequence analysis and according to ICTV guidelines for virus classification, two different types of begomoviruses; *Okra enation leaf curl virus* (OELCuV) and *Bhendi yellow vein mosaic*

virus (BYVMV) were identified in OYVMD infected plants but to amplify DNA- B was failed in any of the tested samples.

Full length of betasatellite DNA in infected okra plant which were collected from each location was amplified with a pair of universal primers and they were cloned, sequenced, and deposited in GenBank. Sequence analysis revealed that the associated betasatellite as *Bhendi yellow vein mosaic betasatellite* (BYVMB).

Furthermore, leaf samples collected from infected okra plants showed positive results to dot blot hybridization using a digoxigenin labelled DNA probe, which had been prepared specifically to detect BYVMB. In the present study, a quantitative PCR (qPCR) assay was developed with primers specific to BYVMB to detect and quantify OYVMD causing agent based on symptom modulating satellite molecules. The method was tested to find out the relationship between symptoms and virus titre in range of severity of OYVMD symptoms. qPCR was able to detect the present of BYVMBs in apparently healthy plants growing in an infected field at a concentration which was not able to detect in end point PCR. Virus titre was also measured in different ages of leaves and different positions. qPCR was tested as a tool to screen the resistant okra varieties and quantify the virus based on copy number of BYVMB DNA in okra varieties subjected to different treatments.

An attempt was made to identify resistant varieties to yellow vein mosaic disease of okra by screening eight different cultivars under field conditions in both *yala,* and *maha* seasons. The disease incidence was comparatively lower in *maha* season than in *yala* season. Most of the cultivated varieties reported higher disease incidence compared to hybrid varieties in both seasons. Furthermore, a field trial was carried out with the above

eight varieties to study the effect of non-pesticidal treatments (neem leaf extract, salicylic acid), beneficial bacterium *Bacillus megaterium*, and insecticide (Thiocyclam hydrogen oxalate) against OYVMD. The plant response against different treatments was not uniform between varieties in both seasons. This result was further confirmed by qPCR assay by quantifying the virus based on copy number of BYVMB in okra plants exposed to different treatments.

Finally, a study was conducted to understand the efficiency of an eco-friendly disease management package on reduction of OYVMD. Okra varieties, TV8 and Haritha were taken in this study and preliminary experiments were done in plant house conditions and later they were tested in field conditions with three crop management practices *viz.* an integrated pest management (IPM) package with non-pesticidal practices, adopting Department of Agriculture (DOA) recommendations, control without the non-pesticidal approaches or use of synthetic pesticides for crop protection. The IPM package tested in the study revealed as an effective management practice towards the management of virus diseases with higher yield. Activity of plant defense enzymes were quantified in above field grown infected okra tissues collected at their mid growth stage. The IPM treatment induces the activity of β-1, 3-glucanse enzyme, polyphenol oxidase, phenylalanine ammonia lyase, and peroxidase in okra crops.

Key words: Defense enzymes, Dot blot hybridization, Integrated pest management, Monopartite begomoviruses, qPCR assay, Resistant varieties, Yellow vein mosaic disease of okra.

IMPROVED WEED MANAGEMENT AND CROP ESTABLISHMENT METHODS FOR RICE GENOTYPES CAPABLE OF GERMINATING UNDER ANAEROBIC CONDITIONS IN DIRECT-SEEDED RICE-PRODUCTION SYSTEMS

by

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ABSTRACT

Poor crop establishment, high weed infestation, and consequent yield losses are major concerns for direct-seeded rice (DSR). Flooding after seeding helps in managing weeds but reduces crop seed germination and crop stand establishment. Anaerobic germination (AG)-tolerant rice genotypes could overcome these problems in DSR. A sequence of experiments under dry-DSR and water-seeded (water-DSR) production systems were established in screenhouse and under field conditions. Screenhouse experiments were conducted to evaluate the effect of seed sowing depth (SD) and flooding depth (FD) on crop establishment, early growth, and weed suppression in dry-DSR using AG-tolerant genotypes. The first screenhouse experiment was established in a split-split plot design within a randomized complete block design with three replicates where three FDs (saturated, 2 cm, and 5 cm), three SDs (0.5 cm, 1 cm, and 2 cm), and four rice genotypes (*Khao Hlan On*, *Ma-Zhan Red*, IR64+AG1, and IR64) were assigned to the main plot, subplot, and sub-subplots, respectively. In the second screenhouse experiment, three FDs (saturated, 2 cm, and 5 cm), two weed levels (weedy and weed-free), and three rice genotypes (*Khao Hlan On*, IR64+AG1, and IR64) were assigned in the main plot, subplot, and sub-sub plots, respectively.

The field dry-DSR experiment was established to evaluate the effect of flooding regimes on emergence, growth, and weed competitiveness of AG-tolerant genotypes. The experiment was laid out in a split-split plot arrangement in a randomized complete block design with three replicates where three FDs (saturated, 3 cm, and 5 cm), two weed levels

weedy and weed-free), and four rice genotypes (*Khao Hlan On*, GSR1, GSR2, and IR64,) were assigned to the main plot, subplot, and sub-sub plots, respectively.

The feasibility of water seeding in tropical climatic conditions in enhancing crop establishment and weed management in wet-DSR were evaluated in field conditions using AG-tolerant genotypes. Two FDs (saturated and 2 cm), two weed levels (weedy and weed-free), and three rice genotypes (*Ciherang*, *Ciherang*+sub1, and *Ciherang*+Sub1+AG1) were assigned to the main plot, subplot, and sub-sub plots, respectively, in a split-split plot design within a randomized complete block design with three replicates. Three weed species including *Echinochloa crus-galli*, *Ludwigia hyssopifolia*, and *Cyperus difformis* were included in the weedy treatments in each experiment.

In the screenhouse experiments, rice plants reached the maximum emergence 9–13 days later under flooding compared with saturated conditions. Crop emergence decreased by 12– 22% at 0.5 and 1 cm SD and by 48–60% at 2 cm SD, when combined with 2 or 5 cm FD compared with saturated conditions. At 2 cm SD, seedling emergence was reduced by 23– 42% in *Khao Hlan On* and *Ma-Zhan Red*, 62–70% in IR64+AG1, and 90–92% in IR64 under flooding. Initial growth in rice plant height was slow under flooding but increased progressively after the seedlings emerged from the water and the final height was not affected by FD. Leaf area, total shoot biomass, tiller density, and leaf number per pot of rice were higher at 1 cm SD (P <0.05) but decreased drastically at 2 cm SD under flooding. The emergence of *E. crus-galli* and *L. hyssopifolia* decreased by 53–65% and 89–95%, respectively, but that of *C. difformis* increased by 49% and 68% under 2 and 5 cm FD, respectively, compared with saturated conditions. The shoot biomass of the weeds followed

the same trend. *Khao Hlan On* showed the highest weed-competitive ability under all FDs while the biomass of IR64+AG1 and IR64 decreased by 10–14% due to weed competition under 2 cm FD.

The results of the dry-DSR field experiment showed that *Khao Hlan On* had the highest number of emergence under saturated, 3 cm, and 5 cm FDs. The emergence of each rice genotype was affected by flooding. *Khao Hlan On* and IR64+AG1 performed similarly (P >0.05) under 3 cm flooding, which was comparatively better than GSR1 and GSR2. The reduced rice emergence under flooding could be attributed to less tolerance of the tested genotypes to flooding and higher anaerobic stress when seeds were sown in a depth of more than 1 cm. Flooding reduced the emergence of *Echinochloa colona*, *Leptochloa chinensis*, *Fimbristylis miliacea*, *Cyperus iria,* and *Eclipta prostrata* by 95-100%. *Spehnoclea zeylanica* and *C. difformis* had their emergence higher compared to other weed species under flooding. The 3 cm and 5 cm flooding reduced the above-ground weed biomass 80-100% at 35 and 49 days after seeding (DAS).

In the water-DSR experiment, *Ciherang*+Sub1+AG1 resulted in more than 280 plants m^{-2} crop establishment, higher leaf area, and higher shoot biomass production under flooded conditions. *Ciherang* and *Ciherang*+Sub1 performed similarly (P >0.05) but, significantly inferior (P <0.05) compared to that with *Ciherang*+Sub1+AG1. The 2 cm FD reduced the emergence of most of the problematic weed species to a greater extent, and the weed biomass accumulation by 95% at 28 DAS and 80-90% until 84 DAS. A few flood-tolerant weed species including *C. difformis* and *S. zeylanica* showed an increased emergence under flooding.

In conclusion, the 1 cm SD showed better growth for all genotypes under different FD. The 2 cm FD is sufficient to have significant control of problematic weed species. The tolerance levels of AG of rice genotypes should be further enhanced to increase their weed-suppression ability. The results of water-DSR and dry-DSR experiments highlighted the probable shift of currently problematic weed flora in DSR by a few of flood-tolerant weed species. Water-DSR with AG-tolerant genotypes would be the best alternative to the wet-DSR especially in areas where complete inundation occurs during initial rice seed germination.

A COMPARATIVE POLYPHASIC STUDY ON VARIATIONS OF
MORPHOLOGICAL, MOLECULAR, REPRODUCTIVE FITNESS AND
PATHOGENICITY OF *Pratylenchus loosi* POPULATIONS OWING TO CHANGING
SOIL TEMPERATURES IN TEA PLANTATIONS OF SRI LANKA

by

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ABSTRACT

The Root-lesion nematode, *Pratylenchus loosi* Loof is the most economically important pest in tea in Sri Lanka. It requires optimal soil temperature range of 18-24 ^{o}C for their development. Under climate change scenario and inferior agricultural practices in Sri Lanka, unusual spread and damage levels of this nematode pest were evident in all tea growing regions which required specific nematode management strategies.

Variations of morphological, molecular, reproductive fitness and pathogenicity of *P. loosi* populations in different agro-ecological regions in Sri Lanka *viz*. PL 1 (Cicilton, Balangoda), PL 2 (Delmar, Halgranoya), PL 3 (Hapugastenna, Ratnapura) PL 4 (Mahadowa, Passara), PL 5 (Nawalapitiya) and PL 6 (Richiland, Deniyaya) were investigated. The nematode population density was also monitored with rainfall, soil temperature and soil moisture in respective locations. Results revealed an increase in mean soil temperature above the optimal range resulting in different symptomological expressions and damage levels in tea.

Contrasting deviations to the existing climatology graphs using data on rainfall, soil temperature and moisture and *P. loosi* populations in respective locationswere seen in the six locations.

Female morphometrics of *P. loosi* showed intraspecific variability and clustered in four groups in Principal Component Analysis where PL 1 and PL 5 were closely related while PL 3 and PL 6 clustered separately with exception of PL 2 and PL 4.

Sequence analysis of D2/D3 expansion segments of the 28SrDNA gene of *P. loosi*populations revealed that PL 3 and PL 6 were closely related while PL 1, PL 4 and PL 5 were relatively distant. Sequences of ITS region of rDNA placed PL 3 and PL 6 in a single clade. The isolates PL 1, PL 2, PL 4 and PL 5 were relatively distantly-related and PL 2 and PL 4 were relatively distant from all populations. Molecular characterization further validated

the closely related PL 1 and PL 5, PL 3 and PL 6 and distantly related PL 2 and PL 4 obtained from morphometric data.

Interestingly, the symptomological expressions of all six populations PL 1- PL 6 behaved differently under field conditions. Studies with soil temperatures adjusted to 24°C, 28°C and 30°C in thermostatically controlled temperature tanks revealed highest *P. loosi* multiplication rate at 24 °C except PL 1 and PL 2 reduced with higher temperatures. PL 1 seemed highly virulent at soil temperature 24 °C showing significantly ($p < 0.05$) higher reduction in plant height (52.3%) and root weight (43.23%). PL 6 however, showed significantly ($p < 0.05$) higher reduction (58.67%) in shoot weight.

Data confirmed that reproductive fitness was not always related with pathogenicity. Reproductive fitness of 61.2, 17.2 and 1.8 at soil temperatures 24 °C, 28 °C and 30 °C respectively showed high sensitivity of PL 4. At 28 °C, PL 2 exhibited a significantly higher reproductive fitness. However, significantly ($p < 0.05$) higher reduction in plant height (59.41%), shoot weight (68.26%) and root weight (59.23%) were observed in PL 3, PL5 and PL 6 respectively. Reproductive fitness at 30°C in PL 2 was significantly higher. Significantly ($p < 0.05$) higher reduction in plant height (55.13%), shoot weight (59.60%) and root weight (57.68%) were observed in PL 5, PL5 and PL 4 respectively. While exhibiting intrinsic reproductive potential of *P. loosi* with soil temperature, high reproductive fitness did not always relate with high pathogenicity.

All study populations except PL 3 and PL6 were genetically divergent and PL 2 and PL 4 were genetically different specific isolates which is corroborated with morphometrics of PL 2 and PL 4 populations being separated to clusters. Hence, morphometrically different and molecularly divergent *P. loosi* populations in tea in Sri Lanka with significantly different virulence and pathogenicity levels triggered by soil temperature variations were proven. This

warranted appropriate nematode management and mitigation strategies in different tea growing regions.

EVALUATING THE PRODUCTIVITY AND STABILITY OF MAJOR RICE-BASED ANNUAL CROPPING SYSTEMS OF SRI LANKA USING APSIM (Agriculture Production system SIMulator)

by

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ABSTRACT

Evaluating productivity and yield stability of crops in water-limited environments and under climate change scenarios is difficult in real field conditions. Modelling approaches can be used as alternative and efficient methods to evaluate the above. APSIM is a simulation model used to study the performance of crops under diverse management and environmental conditions. APSIM-oryza, APSIM-maize and APSIM-mungbean modules were parameterized and validated for widely grown Sri Lankan varieties, *i.e.* short (Bg300) and medium (Bg359) duration rice varieties, local variety Ruwan and hybrid variety Pacific for maize, and variety MI-6 for mungbean, across all three major climatic zones of the country. Historical rainfall data were analyzed to study the changes in rainfall onset and amount of rainfall received in those seasons. Moreover, validated models were used to evaluate the crop and water productivities (CP and WP, respectively) under different management and climate change scenarios.

The APSIM-oryza module estimated the grain yield of rice under moisture-limited farmer-field conditions with a strong fit (n = 24, R^2 > 0.97, Root Mean Square Error (RMSE) = 484 kg ha^{-1}) under a wide range of conditions tested. APSIM−maize and APSIM−mungbean modules also estimated the grain yield with a strong fit for maize (n = 37, R^2 > 0.95, RMSE = 353 kg ha^{-1}) and for mungbean (n = 26, R^2 > 0.98, RMSE = 75 kg ha^{-1}). Historical weather data analysis revealed that the amount of rainfall received was higher when an early onset was occurred (63 % to 94 %) than that

observed with a late onset. Moreover, an early onset resulted longer seasons than the late onset. Farmers regularly established rice crops 2–4 weeks after the rainfall onset.

The APSIM-simulated results showed that the early and late onset coupled with early and late planting, had 33 % and 34 % higher CP, respectively, than when it was not coupled. When the onset of rainfall was delayed, dependency on supplementary irrigation for rice was predicted to be increased. Moreover, late planting with a late onset could result in higher variability in WP (4.3 ± 0.34 kg ha^{-1} mm^{-1}) than that with an early planting and early onset (4.4 ± 0.12 kg ha^{-1} mm^{-1}), even though the mean WP would be similar. The WP (24 %) and CP (10 %) of rice were greater in Alternate Wetting and Drying (AWD) condition in model simulation than those in continuous flooding. It is predicted that the WP of rice-based farming systems could be increased by over 65 % when maize or mungbean extent was increased in water-limited conditions. The most efficient crop combinations to maximize net return were estimated as the diversification of land with 50 % rice and 50 % mungbean sole crops, or 25 %, 25 % and 50 % with rice, maize and mungbean sole crops, respectively. The model simulated that the CP negatively affects the yield stability of rice (33 %) in *Yala* season, and maize (30 %) and mungbean (32 %) in both seasons with changing climate at the end of the century in all three climatic zones, with a greater risk in the Dry Zone.

In conclusion, the parametrised and validated APSIM modules for rice, mungbean and maize showed promising results and could be used in future predictions. Timing of rice planting should be adjusted based on the forecasted rainfall onset to harness the maximum potential of available natural resources. Access to supplementary irrigation with AWD irrigation also increased the stability of grain yield, CP and WP irrespective of the onset of rainfall or time of crop establishment. Selecting best crop combinations can increase the CP, WP and income. As the crop growth and grain yield could be adversely affected by climate change, precautions may take to maintain the stability of crop production.

MORPHOLOGICAL, BIOCHEMICAL AND MOLECULAR CHARACTERIZATION

OF FRUITS AND RAPID MULTIPLICATION OF FIVE SELECTED

BAEL ACCESSIONS [*Aegle marmelos* (Lin.) Correa]

by

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ABSTRACT

The present study addressed the need of filling the knowledge gap in the process of developing bael [*Aegle marmelos* (Lin.) Correa] as a lucrative horticultural crop in Sri Lanka. The objectives of this study were to assess the fruit morphological diversity, optimize the DNA extraction and PCR protocols, assess the genetic diversity using SSR and ISSR markers, assess the bioactivity and phytochemical profiles of the fruit pulp and establish a micropropagation protocol for field grown trees of bael. The elite trees were selected by the Fruit Crop Research and Development Station (FCRDS) of the Department of Agriculture, Sri Lanka based on a nation-wide survey. The five elite trees (i.e. accessions), *Beheth Beli* (BB), *Mawanella* (MA), *Paragammana* (PA), *Polonnaruwa Supun* (PS) and *Rambukkana* (RA) selected in that survey were used as the experimental material in the present study.

PS and RA produced the biggest fruits. PS also owned significantly least number of seeds that are also small and sterile. RA possessed the darkest flesh with the highest Chroma. RA and PA also got the highest pulp percentage, thus could be considered as the best fruit bearing trees. The modified CTAB method yielded a higher amount of DNA than commercial kits, without conceding the quality. The inclusion of spermidine at the rate of 0.8 μM improved the efficiency of PCR by inhibiting polyphenols. The polymorphic SSR and ISSR markers revealed that PA, MA and PS are genetically similar at 98 % of Nei's genetic distance.

The FRAP and DPPH assays revealed that the fruit pulp of accession PA has the highest antioxidant capacity demanding further studies. The bael fruits extracts can prevent the

DNA nicking caused by free radicals through scavenging effects. At 5 mg/ml of fruit extract, RA demonstrated the highest inhibitory effect on DNA nicking and all the accessions demonstrated detectable inhibiting activity under 2.5-5.0 mg/ml of fruit extracts. The antibacterial activity of ethanol and water extracts of bael demonstrated that in general bael possesses similar inhibtion against *Escherichia coli, Staphylococcus aureus* and methicillin-resistant *S. aureus* at 6,000-18,000 ppm which is comparable to an activity of gentamycin less than 0.045 mg/ml.

The best sterilization method was found to be the washing of explants in a 2.5% fungicide solution for two hours. The leaf and twig explants gathered from monthly phenological stages revealed that the successful micropropagation is possible if the explants are harvested during April to May, immediately after the fruiting season of the plant. The full MS and ½MS media provided significantly similar performance in shooting as indicated by the measured parameters. The twig plants did better than leaf explants in shoot extension in which twig explants yielded 1.33 cm taller shoots. The MS medium supplemented with 1 mg/l of BAP generated the highest number of multiple shoots (6.20 shoots) and the most extended shoots (3.83 cm). The most successful rooting (60% success) was observed with full MS supplemented with 1 mg/ml NAA and 3% sugar. The success of acclimatization was 42% which is a higher accomplishment for a woody perennial containing higher amount of polyphenols.

Keywords: Beli, Micropropagation of bael, Antioxidant activity of bael, Antibacterial activity of bael, Genetic diversity of bael