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MESSAGE FROM
THE VICE CHANCELLOR
EASTERN UNIVERSITY, SRI LANKA

It is always a happy day when you have to pen this message for an International Symposium at the University.

It is a prime function of the University to disseminate knowledge and facilitate linkages between institutions and individuals, the key features of the conference too.

"Innovation and Invention on Sustainable Agriculture" is the theme for the conference which blends in with the current United Nation theme of Sustainable development and Poverty alleviation targeted for Achievement by 2030.

I am aware that organizing a Symposium is an arduous task and starts long before the day of the symposium and finish long after the symposium, the long could be many months on either side.

I welcome all the participants International and National for taking the time to join us and visit us. I wish them a fruitful stay in the lagoon environs of the region.

I congratulate the Faculty and the Organizing Committee for undertaking the Organization of the 2nd such symposium on Agriculture, the first for the year at Eastern University and wish the best for the event and its deliberations.

Dr. T. Jayasingam
Senior Professor of Botany &
Vice Chancellor
09.01.2019

MESSAGE FROM
THE DEAN, FACULTY OF AGRICULTURE
EASTERN UNIVERSITY, SRI LANKA

It is with great pride that I write this message on the occasion of the 2nd International Symposium of Agriculture 2919 organized by the Faculty of Agriculture, Eastern University, Sri Lanka. Firstly, I wish to congratulate the Organizing Committee of ISA 2019 for having done an excellent job in organizing this Symposium through their untiring efforts in screening, calling for papers, reviewing them and making the final selection of papers for presentation. This is the 2nd International Symposium being organized by the Faculty to bring together both local and international researchers in tropical agriculture under one roof.

Agriculture plays a vital role in the economy of many developing countries through provision of food for the people, employment and food security to the nation. Agriculture faces many challenges and constraints in the context of climate change and the globalization process that has engulfed the world now. Hence, research activities related to them are vital at this juncture and the efforts of researchers should be directed towards this goal. I wish that this ISA 2019 will bring together researchers for a discussion and networking on the challenges faced by agriculture currently. I hope that the papers presented today will enhance knowledge and suggest solutions for the above issues.

I wish all the presenters and participants a wonderful day at Eastern University and shall remember their visit to Sri Lanka.

Have a pleasant day to all.

Dr P Sivarajah
Dean / Agriculture

MESSAGE FROM THE COORDINATOR/ 2ND INTERNATIONAL SYMPOSIUM ON AGRICULTURE-2019

It is my great pleasure to deliver this message as a coordinator of the second International Symposium on Agriculture (ISA 2019) of the Faculty of Agriculture, Eastern University, Sri Lanka. The first International Symposium on Agriculture (ISA 2017) of the faculty of agriculture was successfully conducted in 2017. Subsequently the faculty decided to conduct the symposium during January each year. Therefore, we pleased to conduct 2nd international Symposium on Agriculture on 09th January 2019, at Eastern University, Vantharumoolai. It has been a real honor and privilege to serve as the coordinator of the symposium. This symposium will provide ample opportunities for discussions, debate, and exchange of ideas and information among conference participants.

I would like to express my appreciation to the Technical Session Chairs and panel members for their valuable contribution in assembling the high quality program. Special thanks to the Keynote Speaker, Dr. Sreenivasa Rao, Principal Scientist at ICAR, Indian Institute of Horticultural Research, INDIA for sharing his views on the symposium theme of 'innovation and invention on sustainable agriculture'. We are also grateful to all the authors who trusted the symposium with their work.

I wish to express my sincere gratitude to the Vice chancellor Eastern University Sri Lanka for giving opportunity to conduct this symposium this year with financial support and Dean Faculty of Agriculture and other officials from the Eastern University Sri Lanka who rendered valuable help to make this event success. I appreciate the editorial committee of ISA 2019 for their great effort in editing the conference proceedings.

M.Sugirtharan
Coordinator/ ISA 2019

CONTENTS

IMPACT OF TEA PACKAGING DESIGN ON CONSUMER BUYING BEHAVIOR

R.A.P.I.S. Dharmadasa, A.M.C. Amarakoon, M.M.B.S. Silva* and S.C. Senevirathne

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Abstract

The tea sector has higher potential to contribute considerably to economic development of Sri Lanka through export earnings. In 2017, contribution to export earning was more than 1.4 billion US$. The production and manufacturing of black tea is of higher importance in this regard. Moreover, in a competitive market arena, the way the product is presented to the customer is also noteworthy. For instance, black Tea Inner Cartons (TIC) are offered to consumer in many forms and it should be presented in attractive forms to catch the consumer favor to the product. Therefore, this study is an attempt to find the effects of selected packaging attributes on the consumer buying behavior and the relationship between social economic factors of the consumer and the tea inner carton buying behavior. A sample of 300 consumers who purchase tea with inner cartons in the Colombo District was taken for the study. Appropriate supermarkets were selected using Judgmental sampling technique while consumers were taken using convenient sampling technique. Primary data were collected by administrated structured questionnaire among the respondents in the sample. Conjoint Analysis was performed to rank the importance of the packaging attributes and to find the best combination of attribute levels. Accordingly, the consumers prefer image and color of the packaging to size and material of the packaging while the most preferred combination of packaging attribute was dark color, large size package with traditional image and artificial material. Most of the consumers prefer green (29.6%), blue (10.3%), yellow (9%), black (7.3%) and red color (7%) inner cartons respectively. Research study recommends that manufactures should focus on the image of the package more than other attributes while giving more emphasis in producing inner cartons having dark color, large size package with traditional image and artificial material.

Keywords: Black Tea Inner Cartons, Conjoint Analysis, Consumer Buying Behavior, Packaging

Introduction

Consumer market for tea products grows rapidly every year and the number of competitors among different types of tea products increases rapidly. Every company tries to increase their customer base and earn more profit. To standout against competitors, every company tries to invent something new and to get the competitive advantage for providing the product to the end customer.

Packaging is a term that comes under the subject of marketing. Products packaging is an element that is commonly used by marketers to emphasis the buying decision of the potential buyers. This common element can also be used for convenience and information transmission and even for differentiation. Package design is one of the most significant parts of product strategy (Ksenia, 2013). It is estimated that approximately 70 percent of all purchase decisions of goods are made at the point of purchase according to Schoormans and Robben (1997). Therefore, the package itself is the only marketing communication the consumer may receive while evaluating the product (Holmes and Paswan, 2012).

The packaging of a product will provide the product within safety. It is an essential element to market the products. Mainly to gain the customer attraction a company or a producer could use the products packaging strategically. The manufacturers should be careful when adding value through the packaging. Recent decade studies focusing on the visual impact of package on consumer attraction include categorization and evaluation as Schoormans and Robben (1997) examined. Packaging plays a vital role in competitive marketing environment. Dividing packaging design elements (size, color, shape, material, etc.) into categories will give good conclusion to the procedures to have good packaging strategy. This can lead to cost reduction and reduction of unattractive elements of a packing design.Identifying what are the effective design elements that influence consumer purchasing behavior and using them to have good packaging strategy to attract consumers becoming more important and crucial for success of the product. Therefore, this research study is conducted to identify the impact of package design elements on consumer purchasing behavior.

Main Objective

- To analyze the impact of packing design elements on consumer buying behavior for black tea inner carton.

Specific Objectives

- To determine the specific features of designing of inner cartons by producer for improvement of designing.
- To analyze the impact of socio economic factors on considering tea packaging designing.

Materials and Methods

The population of our study was Tea Inner Carton customers who live in Colombo area under age group ranging from 20 years to 65 years. Out of the population 300 customers were selected as sample from 15 zones of the Colombo area. Appropriate supermarkets were selected using Judgmental sampling technique while consumers were taken using convenient sampling technique.Primary data were collected through questionnaires among the consumers who purchase tea inner carton products. The self-administered questionnaires consisted of three sections.

- Section 01 : Questions regarding demographic variables
- Section 02 : Questions regarding the package element experience of consumer selection in Tea inner carton (Color, Package Size, Package Material, Package Images, Package Logo, and Package Slogans, Package ingredients information, health benefits, other information, tea type and package type)
- Section 03 : General question on tea inner carton

This research is conducted by taking the buying behavior of the Tea inner carton by customers as the dependent variable. Independent variables of this are color, size, material and image.

Frequency distribution analysis with mean and standard deviation and was used to accomplishment the objectives of the study.Conjoint analysis is a tool which is extensively used for marketing purposes to design or modify the products. The survey was conducted among consumers and they were allowed to rank the attributes levels of the products. Then SPSS software was used to analyze the collected data. It was done to estimate customers' value system. It showed how much value a consumer puts on each level of each of the attributes. Therefore, the product class was divided in to attributes and levels. In Conjoint analysis independent variables are product attributes and dependent variable is buying behavior of the interviewed consumers for the tea inner carton. According to the Table 1, each attribute consists with two levels. All levels which are mentioned in the above table give 16 combinations ($2\times2\times2\times2=2^4=16$).

Table 1: Product Class with Attributes and Attributes Levels

Attributes	Attribute Levels	
	Level 1	Level 2
Colour	Dark	Light
Size	Medium	Large
Material	Natural	Artificial
Image	Traditional	Nature

Fractional Factorial Design

A fractional factorial experimental design was chosen to reduce the number of offerings which were assessed from a full set of 16 to an experimental set of 4. This was conducted in order to reduce the participant fatigue (Orme, 2006). This experimental design preserves more options for additional analysis than the other experimental designs investigated. The creation of more options happens in addition to managing the risk of participant fatigue. The orthogonal design was created and structured using SPSS 21. With using this fractional factorial design, the main impact of each attribute level was identified and the interaction between each attributes was neglected.

Full Profile Approach

The full profile approach was select and used for this study. The approaches help on presenting respondents with a various number of numbers of hypothetical product concepts. Each of the concepts can be described in terms of the specific level for each

factor. The four attributes each with two levels the total number of profiles resulting formal possible combinations of all attribute levels will be $2^4 = 16$, and every profile have been provided with heaviest unique combination of attribute levels. Then consumers are asked to rank or rate these combinations. These data can be utilized to estimate individual utility values (part worth fitting) to each attribute level (Gan, 1992). However, it is difficult to analyze more than five attributes.

Model for the Conjoint Analysis

$$U_j = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

U_j = Total utility of product elements combination
β_0 = The constant term
$\beta_1, \beta_2, \beta_3, \beta_4$ = Part worth consumption
X_1 = Color
X_2 = Size
X_3 = Material
X_4 = Image
ε = Error

Total Utility and Partworth Utilities

Partworth utilities are numerical scores that measure how much each attribute and level influenced the customer's decision to make that choice. The sum of the part worth utilities where part worth utilities defined as the numerical relationship of each attributes levels with consumer preference (Bond, 2001). These utilities could be linear, quadratic or part worth relationships.

Results and Discussion

Descriptive Analysis

Out of the total sample 46.3% are male customers and 53.7% are female customers. With respect to the descriptive analysis, mostly the buying decision of TIC has been taken by females. Most of the tea inner carton users are distributed among age group of 20 years old to 35 years old. 73% of the respondents who possesses education levels more than Advanced Level are using tea inner carton. 55% users of tea inner carton employed in the private sector jobs. The most of the consumers who use the tea inner carton are on the income range of Rs.20000 –Rs.70000. Out of the total sample of the tea inner carton users, 81% considered the price as a significant factor when making the purchasing decision. Out of those 81%, 20% of the customers considered the price are extremely important and 61% customers have considered as important. With this we can judge that the buying decision of the consumers will be thoroughly effected with the influence of the price. While buying an inner carton, 55% of customers considered logos. When considering slogans 40% of customers are considering the slogans that are available in the packaging.

According to the data gathered from the customers are possessing more likeness towards the colors green (29.6%), blue (10.3%), yellow (9%), black (7.3%) and red (7%). The customer consideration on information that is available in a tea inner carton. With referring to these values they are trending closer to each other. These factors are very important in package designing because these factors provide the relevant information about the product to the customer.The packing design considered by the consumers when the buying decision is made. Out of the total amount 78% are considering the package design.

Table 2: Conjoint Analysis (Model Description)

Attributes	N of Levels	Relation to Ranks/Scores
Color	2	Discrete
Size	2	Discrete
Material	2	Discrete
Image	2	Discrete

There are 2 different levels of ingredients have been given in Tablw 2. Relation have mentioned as discrete. This means there is no relationship with increasing and decreasing order with respect to those 2 levels. All these are created in an orthogonal way.

Table 3: Utility Estimate

Attributes	Attribute levels	Utility Estimate	Std. Error
Color	Dark	0.149	0.162
	Light	-0.149	0.162
Size	Medium	-0.112	0.162
	Large	0.112	0.162
Material	Natural	-0.026	0.162
	Artificial	0.026	0.162
Image	Traditional	0.205	0.162
	Nature	-0.205	0.162
(Constant)		8.500	0.162

Estimation of Parts worth Utilities

The higher the utility estimate shows the customer prefers more and more (Table 3). Here there is no any increasing or decreasing relationship, this analysis is more sufficient to evaluate which features are more important and which features are less important to various customers. Part worth utility gives a measurable value for each factor level with a larger proportion of utility values that possess a greater preference. All the above utility values are working as one uniform unit.

Dark colors being preferred more utility compared to light. As a result of that within the color attribute, Dark level (0.149) shows higher utility than the Light level (-0.149).

It implies that, sampled consumers prefer dark colored tea inner carton than light colored tea inner carton. According to psychologists, color likeliness has been derived as a key trait in personality. Large size being given more utility compared to medium. When the size is considered, medium size gives a lower utility level (-0.112), with respective to the large size (0.112), when it contains high level of utility. This implies that when a customer makes the buying decision they give a larger priority to the larger size.

Artificial materials are preferred more compared to natural. With discussing the material attribute, the levels have been derived as artificial material and natural material. With referring the utility level, the natural material using/buying likeliness is at a lower position (-0.026) than using packaging that manufactured by artificial material. Respondents have a high utility towards artificial material (0.026). The basic reasons for this attitude of the respondents are the expectation of durable package and the safety of the product.

Traditional images are more preferred compared to natural images. The image of the packaging is a key attribute that is helpful to achieve the consumer attraction towards Tea inner carton. Image attribute can be divided in to two attribute levels as traditional images and nature. The traditional images contain a high utility level (0.205) rather than for the natural images utility level (-0.205). This is also affected from the physiological levels of the consumers. The values which are expressed in the percentage shows the importance given by the consumers. According to the Table 4, the most important attribute is image. Out of total, it obtains 41.667% as relative importance. It is very important for producers to decide what type of image that they are using in the package in order to advertise their product. Images provide the initial impression to the customer about the product.

The next important attribute is the color out of the total. This indicates that the consumers are considering the color attribute as an important factor. The reason is that when companies are publishing their products they do branding and this branding concept is done in order to capture the recognition of the customer, one of the key components that producer can use to capture therecognition of the customer is the color of the brand and using that color in the products packaging so that the customer could identify the particular product apart from other similar products.

Table 4: Importance of Attributes

Attribute	Score %
Color	30.376
Size	22.760
Material	5.197
Image	41.667

Size is another attribute that is considered by the customers but is not considered much more than the previous both attributes. Size contains the 22.76% value out of the total

attributes. This size has been a concern because it should be convenient for the user and the usage should be supported from the packaging. The least concerned attribute out of the total attributes is the material. The value that is allocated 5.197% out of the total attributes. The material is considered but not in a very high level. This is where the most of the consumers are giving more priority to the size because of the durability of the package.

Table 5: Correlations

	Value	Sig.
Pearson's' R	0.460	0.036
Kendall's' tau	0.100	0.295

As shown in Table 5, the 0.460 means correlations between observed and estimated preferences which is also a course of concern because in some cases probably consumers might have answered these things in a random passion that is the reason of got all kind of combinations which has resulted in a very less correlation.

Conclusions

With specially referring to the tea products in Colombo district it can be certain that there is a positive relationship between packing elements and consumer buying behavior. With relating to the study, the packaging elements can be identified and categorized as color, size, material, image, information of the product logos, slogans, package type and socio economic factors. Out of the total sample 78% are thoroughly considering package design before making the buying decision. Out of that proportion 54% of the female customers are making the buying decision. In addition to that the socio economic factors are also have been effecting this buying decision of consumers. With relating to the pricing, 81% of the concumers are considering the price. When consuming tea most consumers consider on the logos not on the slogans. According to the respondents the most consumer preferable colors are green, blue, yellow, black and red. Out of the total highest amount of responses are given on the color green. According to the Conjoint Analysis the images of Tea inner carton possess highest importance while colors, size have moderate importance and the material of carton have the lowest importance. When considering the attributes levels of the Conjoint Analysis, dark color large size artificial material traditional image packaging could be categorized as the best combination according to the responders. Most of the customers prefer artificial material traditional images modern inner carton packages. The producer should give the priority according to the order of image, then the color, size and finally the material in order to prepare an inner carton package. This order is based on the consumer feed backs so it should be highly considered by the producer. The ingredients, health benefits, other information and logos should be printed on the inner carton in order to give the customer knowledge. Logos are important in packaging while slogans are not significant.

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SOURCES OF AGRICULTURAL INFORMATION USED BY INTEGRATED FARMING SYSTEM PRACTISING FARMERS: EVIDENCE FROM PORATIVU PATTU DS DIVISION, BATTICALOA DISTRICT

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Abstract

This study was carried out to explore the use of agricultural information sources by farmers practising Integrated Farming System (IFS) in Porativu Pattu DS division, Batticaloa district. Questionnaire survey was used to generate data. Data were collected from randomly selected 150 IFS farmers. The collected data were analysed using frequency distribution and percentages as well as Chi-Square test analysis. Among the individual information sources, informal sources are mainly accessed by the IFS farmers which include family members, friends and progressive farmers. Further, field days, demonstrations and trainings were ranked as the main group information sources by the IFS farmers. The study further highlights that among the mass information sources available, the IFS farmers ranked radio as the mostly used source to get integrated farming related information. Furthermore, a significant association ($P< 0.01$) was observed between informal information sources and their regularity of usage. Overall, the study concludes that the IFS farmers in the study area mostly rely on informal information sources to obtain information regarding integrated farming practices, followed by field days and demonstrations organized by relevant departments. The farming community should be encouraged by relevant agricultural support service providers to frequently utilize the agricultural information sources to obtain upto date information on new farming practices.

Keywords: Agricultural information, Informal information sources, Integrated farming, Rural farmers

Introduction

Information is a key factor and vital resource for any development. It is regarded as a basic necessity in daily life, including farming activities (Badiru *et al.,* 2016; Hassen *et al.,* 2012). To make decision, every person needs adequate information (Mchombu and Cadbury, 2006). The access and utilization of information are main two fundamental aspects to achieve agricultural development. As Mchombu and Cadbury (2006) argued, this is mainly due to the fact that agricultural information is not delivered for its own sake but for its use. Rural farmers access and utilize information from available sources for better farming system and improved agricultural yield (Adio *et al.,* 2016). Access to

adequate information is essential to improve agricultural productivity (Mgbada, 2006) and marketing efficiency (Brunnermeier, 2005). According to Alemna and Skouby (2000), the pattern of information access and utilization of rural farmers is complex as these farmers have particular requirements which vary according to resources at their hand.

Agricultural information is not only essential for agricultural development but also to enhance the living standard of rural farmers (Uwandu *et al.,* 2018). This argument is supported by Ronald *et al.* (2015) who see agricultural information as a key factor in improving smallholder agricultural production, thus leading to enhanced livelihoods, food security and national economics as a whole. Agricultural information is defined by Agbamu (2006) as all published or unpublished knowledge in all aspects of Agriculture. Recently, Amaechi and Ossaionah (2015) defined agricultural information as the various sets of information and messages that are relevant to agricultural production activities such as crop production and protection, animal production and management and natural resource production and conservation. The present study was conducted in relation to information utilization pattern of farmers practising integrated farming system and the agricultural information in this study is therefore defined as agricultural related data which are relevant to make effective decisions in integrated farming system related activities.

Farmers utilize agricultural information from various information sources. According to Bisto (2012), the information source is a medium in which information and/or knowledge is stored, whereas Adio *et al.* (2016) view the information sources as tools that can possibly meet the information needs of different kinds of users. Sources of agricultural information can be; radio, television, extension workers, friends and colleagues, magazines, newspapers, books, leaflets, and internet. In addition, speeches, documents, picture and art work can also be described as information sources (Adio *et al.,* 2016). Two categories of information sources have proposed by Koyenikan (2011); formal and informal sources. According to Koyenikan, the formal sources consist of government radio stations, local and international print media (such as newspapers, journals, newsletters and magazines), and seminars/workshops; while family members, friends, and other farmers are included under informal sources of information. A study based on sources of information carried out by Olaniyi *et al.* (2011) demonstrates that interpersonal interaction exists in the rural areas are still of dominant in the dissemination of agricultural information. Further, a very recent study carried out among Sri Lankan vegetable farmers indicates traditional information sources such as progressive farmers, neighbouring farmers and family members remain the most adopted and trusted sources by the farmers (Mahindarathna and Min, 2018). Likewise, another study among coconut farmers in Batticaloa district report that informal sources such as relatives, friends and neighbouring farmers were frequently used by farmers to get coconut farming related information (Selvarajah and Geretharan, 2013). Another study reports that television ranked first among the mass media sources used by the farmers followed by radio in Sri Lanka (Adikari, 2014). However, several scholars (Lokanathan and Kapugama, 2012; Mahindarathna and Min, 2018) reveal that the

usage of mass media as a sources of information was generally low among Sri Lankan farmers.

Integrated farming is the characteristics of subsistence agriculture and longstanding practice across the globe, especially in the developing countries which are dominated by smallholdings (Bhuiya *et al.,* 2014). The Integrated Farming System (IFS) is a term generally and mostly used to explain a combined approach to farming as compared to monoculture methods. The IFS denotes to agricultural systems that integrate crop and livestock production and/or aquaculture. An inter related set of advantages practised in this system, as such the waste from one component turn into an input for another component of the system, which diminishes cost and expands production and income (Soni *et al.,* 2014; Dashora and Hari Singh, 2014). The IFS is one of the major sources of livelihood of many farmers in Porativu Pattu Divisional Secretary's (DS) division of Batticaloa district. As the IFS involves combination of farming approaches, farmers practising the system need adequate and relevant information to obtain optimum benefits from the system. The smallholder farmers practising IFS in the study area obtain information from various information sources. These information sources, for the purpose of this study, grouped into individual, group and mass information sources.

The information sources utilized by farming households in accessing agricultural information related to the IFS are decisive in Batticaloa district, especially in Porativu Pattu DS division, where their primary source of income is agriculture. It is imperative therefore to study the available information sources and pattern of their utilization among farmers who involve in the IFS in Porativu Pattu DS division, Batticaloa district. As such, this study was conducted with the general focus to identify the utilization pattern of agricultural information sources among IFS farmers in Porativu Pattu DS division, Batticaloa district. The following section describes the methodology used for the study.

Methodology

Study Area

This study was carried out in Porativu Pattu Divisional Secretary's division in Batticaloa district. The total area of the division is 167.2 square kilometres of which land area constitutes 150.3 square kilometres. The Porativu Pattu DS division is administratively divided into 43 Grama Niladhari divisions with 120 villages. There are 7, 453 families residing under this division which make up the total population of the division into 43, 579. Agriculture is the major livelihood activity of the population which is supported by three major and medium irrigation tanks and 15 minor irrigation tanks (Statistical handbook, 2016)

Data Collection and Analysis

The study was based on a survey that covered eight villages in Porativu Pattu DS division, Batticaloa district namely: Thumpankerni, Suravanaiyadiyootu, Kanthipuram, Vammiyadiyootu, Kalumunthanveli, Thumpankerni Youth Scheme, Thikkodai, and

Punnaikulam. The study population consists of farmers who engaged in Integrated Farming activities in the selected villages. Based on the number of farmers engaged in Integrated farming activities in all selected villages, a total of 150 farmers were randomly selected to participate in the survey. Primary data for the study were obtained from selected respondents, who responded to the structured questionnaire administered to elicit information related to the study. Secondary data were collected from relevant published sources. The collected data were descriptively analysed to accomplish the objective of study. Scoring was done to rank the agricultural information sources. Further, Chi-Square analysis was done to find out the association between informal information sources and their frequency of usage.

Scoring procedure

A total of sixteen agricultural information sources (individual, group and mass information sources) were presented to the respondents. The sources were measured on a 3-point scale of frequently used = 2, occasionally used = 1, and never used = 0. Respondents were asked to respond to their use of these agricultural information sources in order to obtain score for each respondent. The total score for each information source was calculated by providing points for each variable (*viz* never, occasionally and frequently as 0, 1 and 2 respectively) and multiplying each point by number of respondents obtained the particular point and then by adding up the total points obtained by each source. The mean score was calculated by dividing up the total score for each information source by total number of respondents. The calculated mean score was used to rank the agricultural information sources. The analysed results and findings are discussed in the subsequent section.

Results and Discussion

This section discusses the major findings derived from the study which are related to types of information sources and their utilization. Information sources, which can be individual, group or mass, play a crucial role in disseminating farm related information and adoption of new practices.

Agricultural information sources and their frequency of usage

Results in Table 1 demonstrate the utilization of agricultural information sources by the farmers engaged in integrated farming activities in Porativu Pattu DS division, Batticaloa district.

It can be noted from Table 1, that farmers practising integrated farming frequently got information related to their farming activities from family members (mean score 1.53), followed by friends (mean score 1.36) and progressive farmers (mean score 1.31) among the individual information sources. It could be inferred from this finding that informal communication sources play a vital role in disseminating information among the farmers.These results may be attributed to credibility, easy access and ready availability of these information sources to farmers.

Similar findings also observed by Obeng-Koranteng *et al.* (2017) and Koskei (2012) where relatives, friends and other farmers ranked as important communication sources by farmers. The results of this present study further show that, farmers in the study area also sourcing University (mean score 1.24), NGO officers (mean score 1.20) and extension officers (mean score 1.00) to get information regarding their farming activities. The least utilized individual information sources in the study were neighbours (mean score 0.91) and salesmen (mean score 0.85).

Table 1: Information sources and their frequency of usage (n = 150)

Information sources	Frequency of use			Total score	Mean score
Individual information sources	*Frequently*	*Occasionally*	*Never*		
1. Family members	82 (54.6%)	66 (44.0%)	02 (1.4%)	230	1.53
2. Friends	58 (38.7%)	88 (58.7%)	04 (2.6%)	204	1.36
3. Progressive Farmers	74 (49.3%)	48 (32.0%)	28 (18.7%)	196	1.31
4. University	68 (45.3%)	50 (33.4%)	32 (21.3%)	186	1.24
5. NGO officers	62 (41.4%)	56 (37.3%)	32 (21.3%)	180	1.20
6. Extension officers	34 (22.7%)	82 (54.6%)	34 (22.7%)	150	1.00
7. Neighbours	34 (22.7%)	68 (45.3%)	48 (32.0%)	136	0.91
8. Salesmen	24 (16.0%)	80 (53.3%)	46 (30.7%)	128	0.85
Group information sources					
1. Field days	57 (38.0%)	76 (50.7%)	17 (11.3%)	190	1.27
2. Demonstrations	57 (38.0%)	76 (50.7%)	17 (11.3%)	190	1.27
3. Training programs	68 (45.3%)	46 (30.7%)	36 (24.0%)	182	1.21
4. Group meetings	56 (37.3%)	54 (36.0%)	40 (26.7%)	166	1.11
5. Group discussions	50 (33.3%)	64 (42.7%)	36 (24.0%)	164	1.10
Mass information sources					
1. Radio	54 (36.0%)	56 (37.3%)	40 (26.7%)	164	1.10
2. Newspapers	18 (12.0%)	84 (56.0%)	48 (32.0%)	120	0.80
3. Leaflets	16 (10.7%)	74 (49.3%)	60 (40.0%)	106	0.71

(Source: Primary data)

The findings of this study are in accordance with the study carried out by Hassan *et al*. (2011), highlight that farming communities receive more agricultural information from the interpersonal sources such as friends, family members and village leaders compared to other sources of information.

Among the group information sources, farmers frequently got farming related information from demonstrations and field days (mean score 1.27) followed by training programs (mean score 1.21). It is noted that farmers in the study area are not getting integrated farming related information from group meetings or group discussions. This

may be due to the reason that during group meetings and group discussion, general agricultural information rather than information on specific farming enterprise (in this case about integrated farming system) is discussed. Therefore, farmers are not in a position to fulfil their information needs which based on specific farming practices.

Among the mass information sources, radio (mean score 1.10) ranked first as the most utilized information source for integrated farming in the study area. The second most utilized mass information source was newspapers (mean score 0.80), followed by leaflets (mean score 0.71). Lack of awareness of these information sources could probably be the reason for poor utilization of these mass information sources by the farmers. Further, among these three mass information sources, farmers in the study are getting more information from radio compared to printed information sources (newspapers and leaflets). This may be because printed information sources are not widely used by the farmers due to their low literacy level. Majority of farmers in the study area are low in literacy and unable to read out the information from the printed information sources. Moreover, radio as an effective mass communication source to disseminate agricultural information is very well acknowledged in literature related to developing countries. Muhammed (2005) outlines that smallholder farmers can be rapidly informed about pest and disease attack, weather disasters through radio. Okunade (2007) also emphasizes that radio has its own distinct place in dissemination of information and can play significant role in informing farmers in urgency and emergency circumstances. Recently, Obeng-Koranteng *et al.* (2017) highlight that radio is a convenient medium of mass communication as this source brings flexibility to farmers in receiving the information, who may listen while at farm, at home or elsewhere.

Association between different informal information sources used by IFS farmers and their usage pattern

The informal sources used by the IFS farmers in the study area; family member, friends and progressive farmers, were used to test the association with their pattern of usage; frequently used, occasionally used and never used. Result of the analysis is illustrated in Table 2.

Table 2: Association between informal information sources and their frequency of usage

	Frequently used (%)	Occasionally used (%)	Chi-Square value (X^2)	DF	*P* - value
Family members	38	32			
			50.049	4	0.000**
Friends	27	44			
Progressive farmers	35	24			

*(Source: Primary data) (** P < 0.01)*

There was a significant association observed (X^2 = 53.049; P< 0.01) between informal information sources and their pattern of usage. Among the frequent users of informal information sources, 38% of the farmers discuss with family members to get information regarding the integrated farming system followed by progressive farmers (35%). Meanwhile, 27% of the farmers access friends to get information related to the integrated farming system. Among the farmers who occasionally use informal sources to obtain information regarding the integrated farming system, 44% access friends, 32% discuss with family members and rest of the farmers getting information from progressive farmers in their area. It can be noted from the result that majority of the frequent users of informal information sources go to family members and progressive farmers for sourcing integrated farming related information. On the other hand, majority of the occasional users are sourcing information from family members and friends. As such, family members of IFS farmers considered as a major informal source of agricultural information in the study area.

Conclusions

It is concluded from the study that IFS farmers mostly rely on informal information sources such as family members, friends and progressive farmers to get farming information rather than other individual information sources. Further, field days and demonstrations are the mostly used group information sources by these farmers. Among the mass information sources, radio play a vital role in disseminating integrated farming related information to farmers in the study area. Frequency of usage of these information sources among the IFS farmers should be improved by making these sources easily available and accessible to them. Apart from the informal information sources, other types of information sources need to be improved their competence in disseminating necessary agricultural information to these farmers. The government and other relevant authorities should invest on further improving these sources of information. Besides, the farmers need to be informed and made aware regarding the other available information sources.

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DETERMINANTS OF OFFICERS IN CHARGE TURNOVER INTENTION: A CASE OF KURUNEGALA PLANTATIONS LIMITED

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Abstract

The employee turnover has become one of the major problems causing a challenge to very sustenance of agriculture sector in Sri Lanka. Therefore, it is utmost important to find what causes employees to leave the sector to make relevant policy decisions. Hence, this study attempts to explore the determinants of turnover intention of Officers in charge in one of the government owned plantation companies in Sri Lanka. The data for the study were collected from all the 72 Officers in charge in the company through questionnaires. The data were analyzed using descriptive techniques and Logistic Regression. The results reveal that monetary rewards, additional benefits to employees, satisfaction with human resource management practices and job satisfaction reduce turnover intention. Our results also suggest that young married Officers in charge with prior job experience whose residences located farther from the company and having other income sources tend to leave the job. The study recommended that strategies such as creating conducive job environment, improving housing and infrastructure facilities within work place, supply necessary tools for field work, providing with adequate space and appropriate equipment to perform duties, giving support for employee personal life balance, offering employees with rewards, providing proper job descriptions and developing a succession plan to get promotions should be implemented to better manage human resources and reduce employee turnover.

Keywords: Job satisfaction, logistic regression, turnover intention

Introduction

The employee turnover is the rate at which people leave an organization. Turnover is costly, disruptive and impacts the morale of remaining employees (Armstrong, 2012). High turnover rate among employees signals a major weakness towards organization's achievement. Turnover intention is employee's behavioral intention to resign permanently from current organization (Husain *et al*., 2015). The Sri Lankan plantation sector is a main source of agricultural income. Labor resource is the most important input entering the production process in plantation sector. But with the industrialization, Agriculture sector suffers from high employee turnover rate (Ninan, 1984).

The Kurunegala Plantations Limited is a government owned Plantation Management Company operates in Kurunegala, Gampaha and Anuradhapura districts in Sri Lanka.

The main role of the company is to manage the plantations productively and profitably (Kurunegala Plantations Limited, 2014). The Kurunegala Plantations Limited has been suffering from higher Officers in Charge turnover. It is a considerable barrier to the succession of Kurunegala Plantations Limited (Kurunegala Plantations Limited, 2014).

Skilled and trained employees are economically more important to the plantation sector.However, at present employee turnover has become a burning issue in Sri Lankan plantation sector. This situation is a problem for survival of the organization. There are number of projects conducted to develop welfare conditions and increase wage rates of employees in the Kurunegala Plantations Limited. However, still employee turnover exists in plantation sector. Therefore, it is significant todo research on this area. It is a timely needed study to make relevant policy decisions. Therefore, this study was carried out with the following main and specific objectives.

Main objective

- To determine the factors affecting employee turnover intention

Specific objectives

- To determine the employee related factors affecting turnover intention
- To determine the organization related factors affecting turnover intention
- To suggest strategic solutions to retain employees within the current organization

Materials and Methods

Data collection

The Kurunegala Plantations Limited which suffers from Officers in Charge turnover was selected for the study**.** All 72 Officers in Charge who currently work within the Kurunegala Plantations Limited were used as the respondents for the study.Semi structured questionnaire was used to gather data. The questionnaire consisted with employee related factors, organization related factors and general questions about turnover intention. The study was conducted in two phases. The first phase was conducted as a preliminary survey with a sample of 15 Officers in Charge from which the questionnaire was validated. The pre-tested structured questionnaire contained nine employee related parameters and seven organization related factors. For organization related factors, responses were obtained using five-point Likert Scale with two ends of strongly satisfied and strongly dissatisfied. The second phase was carried out by administering the structured questionnaire among Officers in Charge.

Data analysis

Data were analyzed using both descriptive and inferential statistics. Cronbach's alpha test was used to measure reliability of facet of Likert scale variables. Logistic regression was used to identify the significant employee related factors [i.e. (1) Age (2) Marital status (3) Number of family members (4) Education level (5) Prior experience (6) Job tenure (7) Distance to work place from home (8) Salary and (9) Other Income

availability] that affect turnover intention and to identify the significant organization related factors [i.e. (1) Nature of work (2) Monetary rewards and incentives (3) Co-worker relationship (4) Working environment (5) Additional benefits (6) Human resource management and (7) Job satisfaction] that affect turnover intention. Two logistic regression models for employee related factors and organizational related factors were estimated to find the determinants of turnover intention respectively.

Results and Discussion

Demographic information of the employees

In Kurunegala Plantations Limited all Officers in Charge are males. Where the age is considered, 51% of Officers in charge are within 20-29 years old age category. Most of the Officers in Charge are young. There, most of the aging employees have intention to turnover. Almost half (54%) of the Officers in Charge are married and 46% are unmarried. Majority of the Officers in Charge (34.3%) are educated up to advanced level and completed various certificate courses. Only 3% of the Officers in Charge are educated until Ordinary Level and 4% of the Officers in Charge have educated up to degree level. Half (50%) of the Officers in Charge do not have prior workexperience. More than half (69%) of the Officers in Charge have work experience at the Kurunegala Plantations Limited from 1 to 5 years.

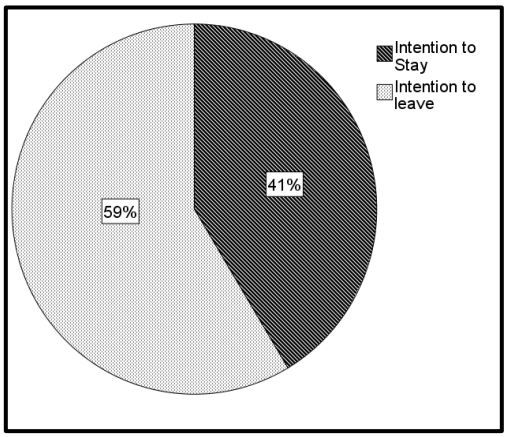

Figure 1: Turnover Intention of Officers in-Charge

There is no high variation in salary distribution observed among the Officers in Charge (Figure 1). Out of the total respondents, 47% of the Officers in Charge are within Rs.15000 - 200000 income group. Certain numbers (30%) of the Officers in Charge have other income sources. The distance between the Officers in Charges' residence and workplace indicates that 37% of the Officers in Charge need to travel 25-50 km to work place from their home and another 13% of the Officers in Charge need to travel up to 75 km from their home.

Forty one percent of the Officers in Charge state that they have intention to stay with the Kurunegala Plantations Limited. The majority of respondents (59%) state that they have intention to leave from the Kurunegala Plantations Limited (Figure 1.).

The Table 1 provides the results of the logistic regression analysis between employee turnover intension and employee related factors. According to the results obtained from the Logistic regression model, age significantly affects the turnover intention (Table 1). The younger Officers in Charge have high turnover intention and elder Officers in Charge have low turnover intention. It may be due to the fact that elder employees cannot move for a new job. But younger employees can move for a new job easily with the experience of present organization.

Table 1: Results of Logistic Regression for Employee Related Factors

Variable	Coefficient	SE	P-value
Age	-0.393	0.135	0.016*
Marital Status	2.586	1.056	0.005**
Number of Family Members	0.074	0.351	0.531
Education Level	0.611	0.388	0.482
Prior Work Experience	0.060	0.155	0.012*
Job Tenure	0.215	0.180	0.050*
Distance from work place to home	0.048	0.017	0.011*
Salary	0.370	0.000	0.589
Availability of other Income	0.048	1.121	0.003**

**Significant at p<0.05 ** Significant at p<0.01*

The coefficient for marital status is positive and significant, indicating that more married Officers in Charge intend to turnover. Unmarried Officers in Charge intend to stay. Married employees are responsible about family. Then, they intend to leave from present job to new job with high salary. The coefficient for prior experience is positive and significant, indicating that more experienced Officers in Charge intend to turnover. This may be due to prior experience that helps them to easily move for a new job. The coefficient for job tenure is positive and significant with the turnover intention. If employees obtain more experience from their present job they can easily leave from present job to a new job. But employees who are new to the organization stay with the organization to obtain more experience.

The coefficient for distance to work place from home is positive and significant. If employees far away from their family they intend to turnover from present job to a new job. But, the Officers in Charge who reside near to the organization stay with current job. Similarly, the coefficient for availability of other income is positive and significant. Availability of other income has a positive coefficient reflecting that

availability of other income increases the turnover intention. If employees have other income sources than monthly salary they intend leave from their present job without future concern.

Results of Logistic regression for organization related factors

The Table 2 provides the results of logistic regression analysis between employee turnover intension and organizational related factors. The results revealed that the turnover intention of employees significantly determined by the monetary rewards, additional benefits, human resource management and job satisfaction.The results further show that there is no significant relationship between turnover intention and the nature of work, co-worker relationship and work environment. The coefficients of the variables, monetary value, additional benefits, human resource management and job satisfaction are negative and prove that there is a negative relationship between turnover intention and the said variables.

Table 2: Results of Logistic Regression for Organization Related Factors

Variable	Coefficient	SE	P-value
Nature of Work	-1.182	0.808	0.143
Monetary Rewards	-1.548	0.554	0.005**
Co-worker Relationship	-0.279	0.522	0.593
Work Environment	0.155	0.585	0.790
Additional Benefits	-2.057	0.773	0.008**
Human Resource Management	-1.357	0.656	0.039*
Job Satisfaction	-1.347	0.658	0.041*

**Significant at p<0.05 ** Significant at p<0.01*

According to the results obtained through the analysis, satisfaction of monetary rewards has a negative coefficient reflecting that availability of monetary rewards decreases the turnover intention. If employees feel there are efficient monetary rewards for their work they are willing to stay with organization. Employees who feel there are no such monetary rewards for their work used to have intension to leave from the organization. Further, negative coefficient of additional benefits is reflecting that availability of additional benefits decreases the turnover intention. If employees feel there are additional benefits they are willing to stay with organization. Employees intend to leave organization if they feel they are not provided with additional benefits.

Employee satisfaction about human resource management has a negative coefficient reflecting that satisfaction about human resource management in the organization decreases turnover intention. If employees are satisfied with human resource management within the organization they are willing to stay with the organization. Employees who are not satisfied with human resource management they intend to leave the organization. Job satisfaction has a negative coefficient reflecting that high job satisfaction decreases the turnover intention. If employees' job satisfaction

increases, they are willing to stay with the organization. Employees who are not satisfied with their job intend to leave the organization.

Conclusions

The overall objective of the study was to determine the factors affecting turnover intention of the Officers in Charge, specific reference to the Kurunegala Plantations Limited.The results of the study revealed that, the turnover intention is significantly affected by employee related factors such as; age of the Officers in charge, marital status, prior experience, job tenure, distance to work place from home and availability of other income. Similarly, turnover intention is significantly affected by organization related factors such as; monetary rewards, additional benefits, human resource management and job satisfaction. Moreover, factors like number of family members, education level and salary have no direct effect on turnover intention. Likewise, organization related factors, such as nature of work, co-worker relationships and work environment have no direct effect on turnover intention of the employees. If plantation sector can provide a better nature of work, work environment and facilitate harmonious coworker relationships among employees, job satisfaction can be effectively improved.

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EXPLORING THE EFFECT OF GOOD AGRICULTURAL PRACTICES (GAP) WITH SPECIAL REFERENCE TO SELECTED VEGETABLES AND FRUITS FARMING: A CASE STUDY IN SELECTED DS IN ANURADHAPURA DISTRICT

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Abstract

Department of Agriculture was introduced the Good Agricultural Practices (GAP) in 2015, and operating on Provincial Agriculturaldepartments, Agricultural Department under Central Government, and Mahawali Project. Over 550 farmers are engaged in GAP in Sri Lanka. In Anuradhapura, 112 farmers applied for this program but only 25 famers received the GAP Certification. For this research, those 25 farmers have been interviewed by the interviewer. The major objective of this study was, to evaluate the economy of the farmers under GAP program and understand how the GAP affect the total yield and total income of farmers. According to the study, it was found that Snake gourd, Bitter gourd, Papaw, Capsicum, Guava and Mango were major crops which cultivated under GAP. Average cost of production of cultivation per acre for selected crops was comparatively lesser than its profit per acre except Guava. Because the yield of Guava was damaged by monkeys. This study revealed that farming under the GAP was profitable because GAP program guided farmers to least application of agrochemicals to the cultivation with appropriate amount at right time. Regular monitoring of farm is essentialto avoid the pest and diseases. Unawareness of existing price for the products produced through GAP was the major limitation, that faced by the farmers. Extension services and farmer's awareness of GAP should be enhanced among the farming population and sales outlets should be opened for the GAP products.

Keywords: Cost, Good Agricultural Practices (GAP), Soil sterilization

Introduction

Most of the time, farmers used to apply high dosage of agro chemicals in their cultivation and these agro chemicals contain heavy metals. Those accumulated in human through food chain and cause many health problems such as chronic kidney disease, cancers etc. Such types of agricultural commodities (vegetables and fruits) exported from Sri Lanka for foreign exchange are sometimes rejected by the foreign countries including Europe. As a solution to these, Department of Agriculture initiated the Good Agricultural Practices (GAP) in 2015, and operating through Provincial Agricultural Departments.

Over 550 farmers are currently engaged to use Sri Lankan GAP, which will be a natural graduation to receive global certification. Nowadays, most of farmers focus on farming of vegetables and fruits through Good Agricultural Practices (GAP) (EDB, 2013). This research dealt with the economic analysis on small scale farming of selected vegetables and fruits which follow GAP in selected Divisional Secretariats in Anuradhapura district, Sri Lanka. The objective of this study was to find out the status of GAP program of selected vegetable and fruits production in the Anuradhapura district.

Materials and Methods

This study consists of descriptive research design along with the quantitative and qualitative data (interviewed responses) that shows economic status of GAP farming of fruits and vegetables in selected divisional secretariats of Anuradhapura district. Descriptive statistic is used to describe the basic features of data which studied. Purposive sampling method was used to select the sample population to collect the data. The sample that is selected based on features of population and objective of study.

Study Area

This study was carried out in Anuradhapura District. There are 22 Divisional Secretariats with total population of 856232. Target population for this study was small scale GAP farmers in major selected Divisional Secretariats (which famous for GAP agricultural activities) in Anuradhapura District such as, Madawachchiya, Rambawa, Manupa, Thambuththegama, Thalawa, MahaVilachchiya, Kakirawa, Palagala, Galnewa, Nochchiyagama and Galenbindunuwewa (Figure 1).

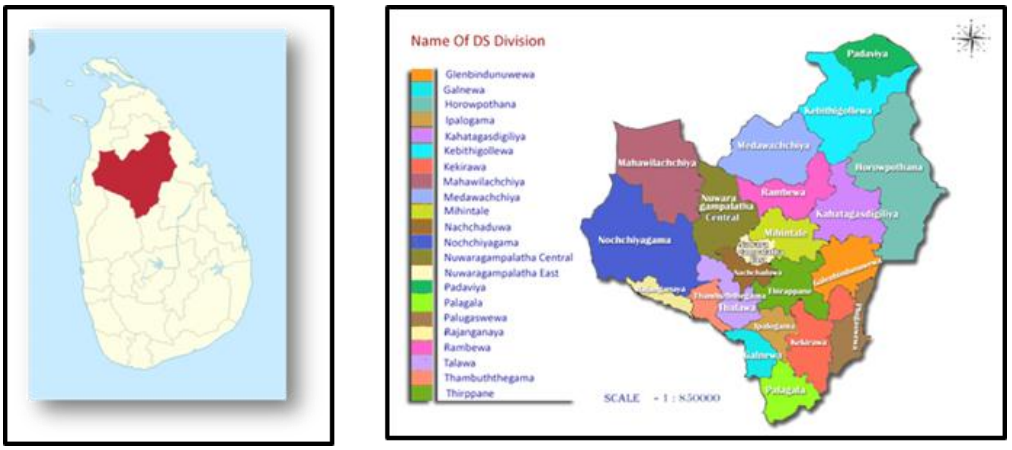

Figure 1: Study Area, Anuradhapura district

Selection of samples

The sample was selected among people who are engaged in small scale farming of Good Agricultural Practices program which is conducted under Provincial Department

of Agriculture, Anuradhapura. Altogether, there are 112 farmers are included in this program. Among those only 25 farmers received the GAP Certification. Those 25 farmers have been interviewed by the interviewer. Farmers grew snake gourd, capsicum, bitter gourd, papaw, guava, and mango using good agricultural practices (GAP).

Primary data

Primary data were collected using questionnaire from small scale vegetables and fruits growers under GAP program. 5 questionnaires were distributed among the farmers in Medawachchiya divisional secretariat to pretest the questionnaire. Finally, 25 farmers were interviewed using structured questionnaires

Secondary data

Secondary data were collected from different sources such as, Department of Agriculture (Provincial), Agricultural Instructors of respective divisions, Agricultural Development Officer (GAP) Anuradhapura and published reports, research articles, books, GAP Manual, journals and internet sources.

Data Analysis

The data was entered in Microsoft Excel 2010. Then, statistical analysis was done using SPSS software. Descriptive statistics were used to analyze the socio-economic status of GAP. It provides frequency and percentage of response for each variable.

Independent sample t – test

Independent sample t-test was done to compare the differences in yield of vegetables and fruits with different Good Agricultural Practices. The following null and alternative hypothesis was set before the t- test.

Null hypothesis (H_a): There is no significance different in the mean yield (kg/ac).

Alternate hypothesis (H_0): There is a significant different in the mean yield (kg/ac).

Results and Discussion

Socio Economic features of Small Scale famers practicing Good Agricultural Practices (GAP)

Age is the main character of life that express how people can actively involve in various farming practices. The mean age of the sample was 50.44 and the minimum and maximum was 36 and 69 respectively (Table 1).

Table 1: People involved to fruit and Vegetable farming with Age

	No of respondents	Minimum	Maximum	Mean
Age (in years)	25	36	69	50.44

Generally, education level affects the selection of appropriate scientific technology. It recognizes that higher achievement for education provided greater social and decision making ability within society. Most of the farmers were within 11-13 years of schooling (Table 2). According to the field survey 80% of farmers involved farming as their full time occupation and 20% involved as their part time occupation (Table 3).

Table 2: Education Level of Farmers

Education Level	1-5	6-10	11-13	Higher Education
No of farmers	2	7	11	5

Table 3: Farmers involvement for farming

Farmers involvement for farming	No of farmers	Percent
Full time occupation	20	80.0
Part time occupation	5	20.0

Types of GAP practices among the study population

All 25 farmers were practicing all the GAP guidelines from seeds/seedlings collection to harvest except ploughing, planting of barrier crops, soil sterilization and covering of fruits and vegetables**.** Covering of fruits and vegetables was adopted with objective to enhance the product quality and protection from pest and diseases (Table 4).

Table 4: GAP practices

Type of GAP practices	Yes	No
1. Ploughing	12	13
2. Planting of barrier crops	2	23
3. Soil sterilization.	5	20
4. Covering fruits and vegetables	20	5

Type of labour for each GAP practice

Table 5: Type of labour

	Following	Not Following	Hired men	Family labor
Ploughing	12	13	12	0
Apply Compost	25	0	8	17
Sterilization	4	21	4	0
Making Planting Holes	25	0	25	0
Irrigating Fields	25	0	7	18
Apply Pesticides	25	0	25	0
Covering Fruits	20	5	20	0
Harvesting	25	0	25	0

All farmers were used hired labour for application of compost, making holes for planting, irrigation to field, application of pesticides, and harvesting. 12 farmers used

hired labour for ploughing. 4 famers practiced soil sterilization and all were hired labour. 20 farmers followed covering of fruits and vegetables and those were also hired labour (Table 5).

Application of compost

All 25 GAP farmers stated that they were added compost frequently in the initial stage of cultivation. They incorporate compost with other fertilizer and organic manure to the soil. Adding compost and other organic manure is essential at the initial stage to increase the efficiency of fertilizer. 18 farmers were adding compost to the crops in the intermediate stage. 7 did not apply compost in this stage. Intermediate stage is the time that plant shows its rapid growth. Therefore, adding compost enhance the efficiency of nutrient uptake from the soil (Table 6).

Table 6: Application of compost in each stage

Crop Stage	No of respondents	
	Yes	No
Initial	25	-
Intermediate	18	7
Harvesting	2	23

Yield observed among GAP farmers

The table 7 shows the yield level among different vegetable's and fruit's of GAP practitioners. Capsicum showed the highest average yield of 14000kg/ac. There were 3 farmers. All 3 capsicum farmers were practiced intensive methods of cultivation. Papaw yield was 6666 kg/ac and there were 2 farmers involved in Papaw production. 9 farmers practiced snake gourd and yield was 2027 kg/ac. Only 1 farmer was involved in bitter gourd production and yield was obtained as 4000kg/ac. 5 farmers were followed guava cultivation and average yield was 536kg/ac.

Some guava farmers stated that they lost their average yield because of monkey problem. Mango yield was noticed as 8800kg/ac. Some mango growers lost their average yield due to prolonged drought.

Table 7: Last season Average Yield (Kg/ac)

Crop cultivated	No of respondents	Average yield (Kg/ac)
Snake gourd	9	2027
Bitter gourd	1	4000
Capsicum	3	14000
Papaw	2	6666
Guava	5	536
Mango	5	8800

Profit level of crops among GAP practitioners was comparatively higher, except guava. During the harvesting stage of guava, farmers had been faced monkey attack. Because of that they lost their profit (Table 8)

Table 8: Profit from each crop (Rs/ac)

Crop cultivated	Average Income (Rs/ac)	Average Production Cost (Rs/ac)	Profit (Rs/ac)
Snake gourd	219692	38056	18163
Bitter gourd	880000	29330	850670
Capsicum	2240000	852800	1387200
Papaw	933333	141933	791399
Guava	34600	124466	89866
Mango	97321	66412	30908

According to the results of independent sample T-test: Effect of different Good Agricultural practices and Total crop mean yield at 5% significance level.

Difference in yield by GAP in t- test

Among the different GAP adopted, soil sterilization caused difference in yield among the adopters and non-adopters. The mean yield of 7460 kg/ac was observed among soil sterilization practitioners. The non-adopters received the mean yield 2287.50 kg/ac which is significantly ($p<0.05$) lower than the yield of adopters (Table 9).

Table 9: Independent sample t-test

	Soil Sterilization	Mean	t-test for Equality of Means Sig. (2– tailed)
Yield (kg/ac)	Yes (05)	7460.00	.034**
	No (20)	2287.50	

** significance at 5% significant level.

Ploughing and Planting crops with pest deterring value or barrier crops were not affected the total mean yield of fruits and vegetables at 5% significance level.

Soil Sterilization was affected the total mean yield of fruits and vegetables 5% significance level.

Conclusions

This study has revealed the state of small scale faming of fruits and vegetables through Good Agricultural Practices (GAP), Anuradhapura district. GAP has contributed to enhance the living standards of farmers as well as consumer's health. Growing of fruits and vegetables through Good Agricultural Practices may reduce the risk of health problems. According to the study it was found that GAP farming is profitable. Soil sterilization as a GAP effects on increasing the total mean yield. Extension services and farmer's awareness on GAP should be enhanced among the farming population and sales outlets should be established for the GAP products.

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SUSTAINABLE ECOTOURISM DEVELOPMENT: A CASE STUDY IN MANDAITIVU ISLAND, JAFFNA

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Abstract

In spite of degradations of natural resources by anthropogenic activities and lack of apparent options, there are potentials for ecotourism development in Mandaitivu Island. The ecotourism improves the livelihood of local communities and conservation of natural resources. The major objective of this study was to analyze the potential of sustainable ecotourism in Mandaitivu Island. The study was conducted through a field survey using convenience sampling method interviewing 120 target participants. According to the study, the main potentials for ecotourism opportunities available in the Mandaitivu Island include diversified species of birds, some mammals, scenic landscapes, mangrove forests, sea grass beds and stunning beaches. Mangrove encroachment, sand mining and expansion of farming activities were revealed as the major problems contributing to the degradations of natural resources of the island. The study has identified the income generating alternatives through potential ecotourism opportunities which could help to reduce the present degradations of natural resources. The analysis of the study were carried-out by Wilcoxon signed rank test and descriptive statistics that exposed, there is a positive attitude among the 68.3% of the local community towards ecotourism. Further the outcome of the study conducted shows there is a significant among people to protect the natural resources (P: 0.0007) and ecotourism will lay a path for more employment opportunities (P: 0.0000) for the youth of this local community. People who reside in the local community agreed with the idea of the implementing ecotourism in a well positive manner, however they require more education on environment (P: 0.0000) to understand the concept of ecotourism and to support cause. Tourism will improve the access to attract ecotourism locations and stimulate the development of new facilities infrastructure and communication. However, some negative impacts mainly cultural modification and secondly waste accumulation can be an adverse impact for the ecotourism. Finally, introducing sustainable ecotourism is an important strategic direction for sustainable management of natural resources and improving alternative economic opportunities in Mandaitivu Island.

Keywords: Alternative opportunities, Local community, Mandaitivu Island, Natural resources, Sustainable ecotourism

Introduction

Tourism is one of the most important contributors to the Sri Lankan economy. In Sri Lankan economy, tourism continued as the third largest earner of foreign exchange earnings. Tourism, which forms 0.6% of the total GDP of the country, was one of the fastest growing sectors in the economy, growing by 39.8% in 2010 over 2009 (Sri Lankan Tourism Industry, 2011). Jaffna is one of the districts of Northern Province of Sri Lanka. It has more tourism potentials to develop the province, which was untouched for the past thirty years. It is vital for Jaffna to adopt the concept of going green as it is the appropriate time to develop ecotourism throughout the country (Mathivathany and Sasitharan 2013.).

In Mandaitivu, the majority of its population are engaged in fisheries and agricultural activities instead of ecotourism activities. Alternative way of income generations mainly from ecotourism activities help to minimize degradations pressure on lands, endangered species and fragile environments in Mandaitivu Island. In order to make tourism sustainable in Mandaitivu, this case study attempt to identify the opportunities for development of ecotourism and creating diversified livelihoods for local people. Adding on to these natural resources available in Mandaitivu can provide economic boost through ecotourism development. As off now Mandaitivu Island has not been developed as a tourist destination. There are more chances to create and develop a stable ecotourism in the potential tourist destination Mandaitivu. If a tourist destination has an unsustainable development, then environmental degradation is inevitable. This case study identifies the need to create an alternative activity that people can participate in and is more environmentally conscious. As a predominantly nature oriented destination, Mandaitivu Island has the potential to be a sustainable ecotourism destination which would help to promote livelihood opportunities and protect the environment from natural resource degradations.

The general objective of this research was to identify and analyze the potential of sustainable ecotourism development in Mandaitivu Island, Jaffna. Specific objectives were: To analyze the major issues supporting to the development of ecotourism;To identify the constraints related with sustainable ecotourism development and make suggestions to develop thesustainable ecotourism capabilities and ecotourism activities in that area.

Research Methodology

Mandaitivu is an island off the coast of Jaffna peninsula in northern Sri Lanka, located approximately 7 Kilometers south of the city of Jaffna. The island has an area of 7.56 Km^2. According to the climate Mandaitivu Island belongs to dry zone with an annual rainfall of 1235 mm and with monthly air temperature of 27.7 º C. The survey was performed in Mandaitivu South, East and North. Sixty local residents were selected in particular destination for the study. Further 60 local and international tourists were also selected for the survey.

Conceptual framework

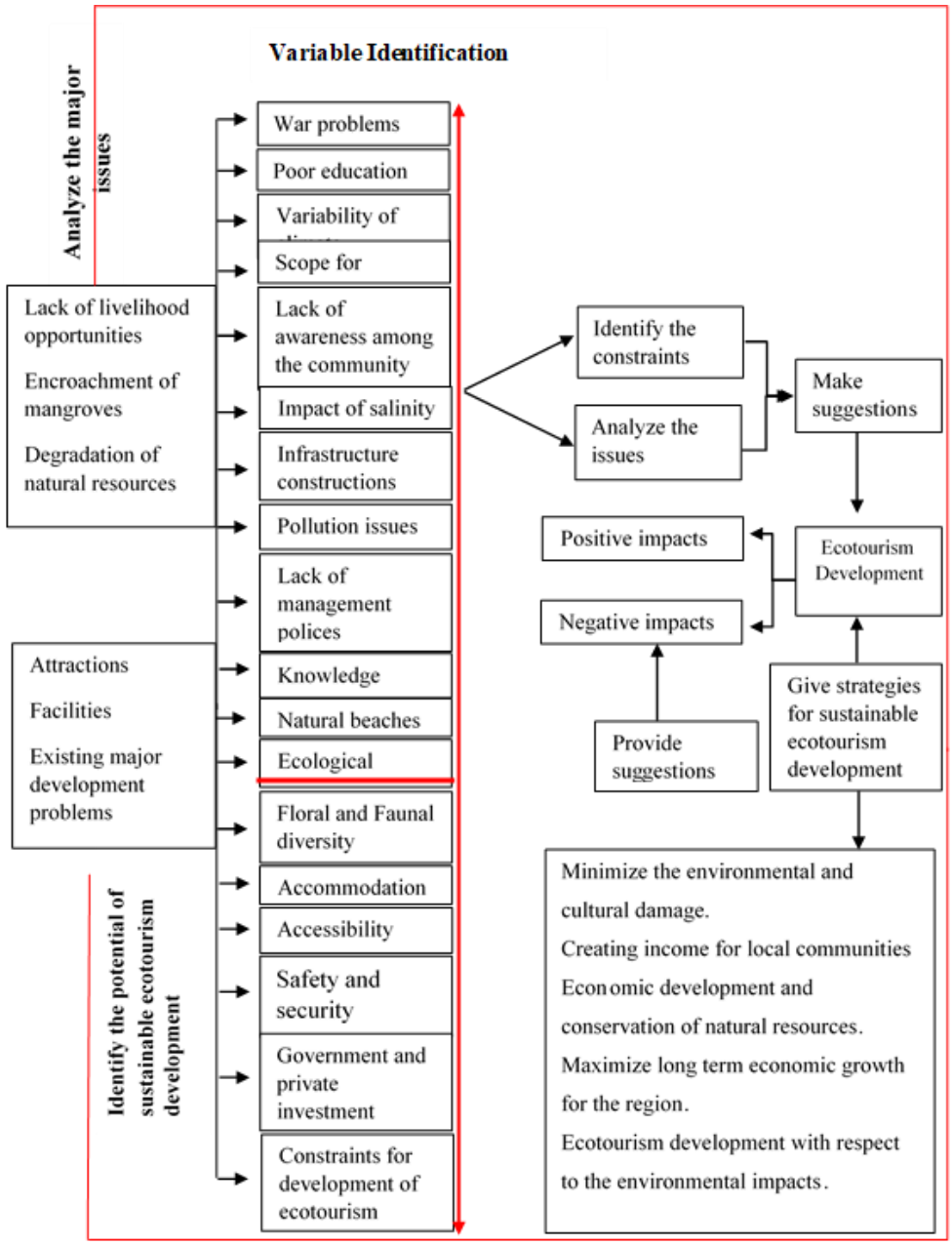

Figure 1: Developed conceptual framework based on objectives

Convenience sampling method was used for the survey and the study was mainly based on the primary data. Data were collected through structured questionnaires from selected sample. A questionnaire was developed in order to disclose key indicators which are related to independent and dependent variables to achieve research

objectives. Primary data were collected through self-administrated two different kind of questionnaires among the community people and tourists in Mandaitivu Island.Data were analyzed by using appropriate descriptive statistical tools and applicable inferential statistical tools. Chi square test was used to investigate the relationship between the dependent and independent variables. Wilcoxon singed rank test was applied for the analysis of Likert Scale survey questions.

Results and Discussions

Attitudes towards sustainable ecotourism

Dataanalysis revealed that nearly 68.33 % of the respondents had positive attitudes, while 31.67 % had negative attitudes about sustainable ecotourism development in the region. The results have been shown in the Figure 2.

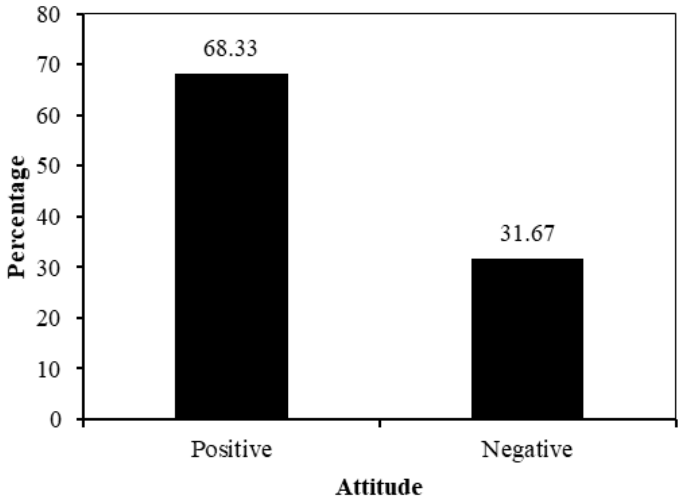

Figure 2: Attitudes toward ecotourism

Positive attitudes were received towards economic and social consequences such as infrastructure development, public facilities, and social welfare, employment opportunities. Negative attitudes were received towards unfavorable consequences such as cultural modification, waste accumulation and resource degradation. The major reason behind the negative attitude was the fear of their cultural modification.

Respondents' attitudes associated with demographic variables

Table 1: Demographic variables vs. respondents' attitudes

Variables	Positive attitude	Negative attitude	Chi-square value	P value
Gender				
Female	17	8	0.002	0.963
Male	24	11		
Age				
18-24	8	5	0.752	0.861
25-34	12	5		
35-44	9	5		
45	12	4		
Education				
Primary	6	8	8.417	0.000*
Secondary	16	8		
High school	12	3		
Degree	5	0		
No schooling	2	0		
Occupation				
Farming	14	3	3.747	0.441
Fishing	5	5		
Student	8	5		
Not employed	5	3		
Other	9	3		
Length of residency				
All my life	30	16	0.347	0.885
More than 20 years	11	3		

Significant at P = 0.05

Identify and analyze the potential of sustainable ecotourism development

Attractions

According to the results (Table 2), "Island is suitable for beach based activities" positively and significantly. That means there is a significant potential for suitable beach based activities in that area. "Environment is rich biodiversity and high value destination". And question "Development of ecotourism will give benefits for this area" answered positively and significantly. These results also compatible with the findings of Keshini De Silva, (2017) that indicated Mandaitivu has the potential for nature related activities and rich in bio diversity. The question "Tourism destination respect the natural environment" was not answered positively.

Table 2: Questions about attractions in the site

Questions	Mean value	P value
Suitable for beach based activities	1.7667	0.0000*
Environment is rich in bio diversity and high value destination	1.0833	0.0000*
Tourist destination respect the natural environment	-0.1170	0.6780
Development of ecotourism will give benefits for this area	0.5830	0.0000*

**Calculated P value < P 0.05, significant*

Facilities

According to the Table 3, most of the tourists felt disagree for all statements. For the question "Enough safety and security facilities available in Mandaitivu" they felt "Enough accommodation facilities available around this Island" and "Enough transportation facilities available within Mandaitivu" are negatively significant. The question "Enough transportation facilities available from Jaffna to Mandaitivu" has been received positive response.

Table 3: Questions about facilities available in the site

Questions	Mean value	P value
Enough transportation facilities available from Jaffna to Mandaitivu	0.4170	0.1156
Enough transportation facilities available within Mandaitivu	-1.3670	0.0000*
Enough accommodation facilities available around this island	-1.5830	0.0000*
Enough safety and security facilities available in Mandaitivu	-1.1833	0.0000*

** Calculated P value < P 0.05, significant*

Analyze the major issues supporting to the development of ecotourism

Lack of livelihood opportunities

According to the Table 4, the majority of respondents mentioned "unemployed youth of this area will get alternative livelihood opportunities by this ecotourism development" which is highly significant. Tao and Wall (2009) reviewed that, sustainable livelihood approach is useful because it acknowledges particularly in communities, people gain their livelihoods through ecotourism activities rather than one formal job. If a community decides to incorporate tourism as one of their livelihood strategies in order to achieve sustainable livelihood, tourism will be a form of livelihood diversification. Community people that they felt "Regional development increasing the level of living standard and self-esteem of local people" is also highly significant. Answer for the question "Tourism will promote local products and services" is not significant. Hence question "community people support the need of

ecotourism in this region" most of the people reacted neither agreed nor disagreed for this statement. The P value for this statement is however not significant.

Table 4: Questions about lack of livelihood opportunities

Questions	Mean value	P value
Community people support the need of ecotourism	0.0830	0.5181
Regional development increasing the level of living standard and self-esteem of local people	0.7830	0.0000*
Unemployed youth get livelihood opportunities	0.9670	0.0000*
Tourism will promote local products and services	0.1000	0.4326

** Calculated P value < P 0.05, significant*

Mangrove, natural resource degradation

According to the Table 5, majority of the community people significantly mentioned that they were felt "environmental education is important on natural resource to the local people". They felt "tourism development will increase the pollution and salinity level on the environment". And the majority of the tourist mentioned that they felt "Infrastructure developments increasing the level of Mangrove destruction". Hence, Question "Tourism will promote Protection of natural resources of this region" most of the respondents felt agree this statement. According to Sunlu (2003)tourism can significantly contribute to environmental protection, conservation and restoration of biological diversity and sustainable use of natural resources.

Table 5: Questions about mangrove and natural resource degradation

Questions	Mean value	P value
Infrastructure developments increasing the level of mangrove destruction	0.1170	0.1907
Tourism development will increase the pollution and salinity level on the environment	0.4830	0.0309*****
Tourism will promote protection of natural resources of this region	1.0170	0.0007*****
Importance of environmental education regarding natural resource to the people	1.2170	0.0000*****

** Calculated P value < P 0.05, significant*

Existing major development problems

According to the Table 6, "Government and NGO provide fund for develop Mandaitivu", "Government and private sectors are help to create new job opportunities and promote local products in Mandaitivu" In these following statementsmost of the local people exactly did not know the situation and they felt neither agree or disagree. Those statements are not significantly. Most of the people positively and significantly reacted in a less involvement manner to the question of "There is high political influence in Mandaitivu tourism development".

Table 6: Questions about existing major development problems

Questions	Mean value	P value
Government and NGO provide Fund for develop Mandaitivu	-0.0830	0.4901
Government and private sectors are help to create new job opportunities and promote local products in Mandaitivu	-0.1170	0.3290
There is high political influence in Mandaitivu tourism development	0.2333	0.0312*****

** Calculated P value < P 0.05, significant*

Conclusions

The research revealed that local residents perceived ecotourism activities in the case study area will bring many benefits both the village and villagers. Diversified livelihood and alternative options mainly local handicrafts, guiding services, local drinks and foods are the indicators of ecotourism potentials and could be provided by local communities. Tourists are less attracted to the Mandaitivu Island because of the lack of basic facilities. Establishing facilities will give benefits to the local people and the visitors of this area, in such a way probability of getting livelihood opportunities will increase to the younger generation of this area. This research identified several potentially negative consequences of ecotourism to which attention needs to be paid. These existing adverse impacts of increasing levels of waste disposal in and around the sea; pollution; resource degradation are the challenges that have been a major threat to ecotourism practices in the area. Another major negative consequence of the development of ecotourism in Mandaitivu Island is cultural modification, and younger generation of this area will undergo a mass change in their behaviors. Some management problems on natural resources mainly mangrove encroachment, sand mining, social related problems and lack of fresh water sources these are major threats to natural resources of study area. Infrastructure development mainly road, building constructions will lead to mangrove encroachment in that area. Government negligence and ignorance in the past development programs in tourism activities in Mandaitivu Island, have made people of this area dissatisfied. The people believe that there will be no systemically improvement in ecotourism due to the ignorance and corruption of government officials.

Recommendations

Developing and creating diversified livelihood, promoting the development of ecotourism, encouraging benefit sharing and conservation of natural resources of the particular destination will lead to reach the potential benefits of ecotourism in a substantial way. Mangrove forests of the study area may degrade as fuel wood due to this, there will be a pollution in the study area. Therefore, the hotels and developmental activities are advised to develop the solar energy and biogas in substituting for consumption of fuel woods to prevent deterioration of mangroves and avoiding resultant pollution. Increasing the awareness of local communities in Mandaitivu Island

towards ecotourism is very important. Therefore, such awareness about environmental education might be affected. Illegal activities mainly sand mining, mangrove destruction will be a threat on natural resources of this area. Therefore, government should undertake and regulate strict policy on environmental act and natural resources conservation act. Involving the community is a critically important component in a successful ecotourism program. Hence community participation in all aspects of ecotourism activities should be ensured. For the enhancement of the economic standard of the community, educated youth in the villages should be trained and employed. Tour operators should use appropriately trained local residents as interpreters and should encourage the tourists to buy local products. Encouraging and incorporating local residents' concerns into the decision making process can serve to build local residents' self-confidence and enthusiasm. Local villagers' effective involvement in the ecotourism activity can be accomplished through identifying and strengthening their capacities.

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ADOPTION OF MACHINERY IN TEA CULTIVATION AND MANAGEMENT BY TEA SMALLHOLDERS IN KALUTARA DISTRICT

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Abstract

Use of machinery is a vital investment to enhance the productivity and overall performance of the tea industry.It is considered to be a better solution for the problems of labor shortage and high cost of production. However, what factors determine the level of adoption of machineries is questionable. Therefore, taking 154 tea smallholders representing 4 smallholder societies of 4 Tea Inspector (TI) ranges, this study was conducted to find the determinants of adoption level of machinery. The sample for the research study was selected using multistage sampling technique. The data were analyzed using descriptive techniques and three regression models; Tobit and Logistic Regression. According to the results of the descriptive analysis, overall adoption level is 12.73%. Smallholders have higher adoption on pruning machine (29.22%) and TRI selective tea harvester (20.13%) while lower adoption is recorded on Holing machine (7.14%), Fuel operated plucking machine (5.19%) and Battery operated plucking machine (1.95%). The results of Tobit and Logistic regressions reveal that young male tea land owners with sufficient experience in cultivation who uses family labor and extension facilities from Tea Research Institute tend to adopt machineries. Our results also suggest that they tend to use more machineries if their tea yield is higher. However, more educated tea smallholders do not tend to use machineries while time spent on tea land for management practices also reduces the machinery usage. The decisions to adopt the machineries do not depend on the extension facilities given by the TRI while the tea smallholders who adopted the machineries seek more information. Therefore, it is recommended to improve and strengthen the extension facilities to gain productive gains from the use of machineries.

Keywords: Adoption level, Kalutara District, Machineries, Tea smallholders

Introduction

The commercial tea plantations in Sri Lanka has over 150 years of the plantation history to build the name of Ceylon tea. Tea continues to remain as the major plantation crop in the country and provides substantial support to the national economy. The total production of the Tea Small Holding sector 239.86 million kg per year. The contribution to the national production was about 73%. (Tea Small Holding Development Authority, 2015). Lands less than 10 acres in extent are treated as “tea

small holdings" according the tea control act. Though the plantation estate sector is rather stagnated, the small holing sector has performed better during the past few decades (Basnayake and Guneratne, 2002)

In the past few decades, there are some critical issues in tea industry such as lower productivity, high cost of production, a decline in the quality of made tea, technologized issues and negative attitudes of the associates in tea industry that has been to a leading labor shortage (Dissanayake and Athauda, 2011).The concept of machinery usage is an innovative potential to the tea small holding sector as a best solution for labor shortage, low productivity and high cost of production. Therefore the tea small holding sector is looking for a better approach from machinery usage to obtain high quality and low cost output for long term survival of the tea industry in Sri Lanka.

TRI[1] selective tea harvester (TRI shear), Fuel operated machine harvester, Battery operated machine harvester, Pruning machine and Holing machine are machineries introduced for tea cultivation and management practices. In case of encouraging sustained agricultural intensification and enhancing the land productivity (Kienzle *etal*., 2013) in an era of much young blood moves away from agricultural sector (Dissanayake and Athauda, 2011), machineries may be of great interest to smallholder farmers as the adoption of machineries in their production within the limited land extent may lead to save cost and reduce drudgery (Kienzle *et al*., 2013). Use of such machineries also help facilitate the conservation of resources (Krupnik *et al*., 2013). However, the question remain as to what factors are associated with smallholder adoption of those machineries. To answer the question, it is necessary and important to understand the farm level characteristics, household characteristics and availability of extension services. Therefore, this study sheds lights in determining the factors affecting the adoption level of and decision to adopt machineries available to tea smallholders in Kalutara District of Sri Lanka.

Materials and Methods

Kalutara district has 7,823 ha of total extend of tea small holdings and 35, 908 number of tea small holdings (Tea Small Holding Authority, 2015). The survey was carried out in Kelinkanda, Meegahathenna, Galmaththa and Thinniyawala "Pragathi" tea small holding societies. As those above societies have largest number of tea small holders. There were 3100 of tea small holdings in above selected societies. This study was conducted using 154 tea smallholders connected to those societies in Kalutara District**.** The sample for the research study was drawn using multistage sampling technique. Data were collected using structured questionnaire and interviewing the tea small holders at their residences. Production factors, household level characteristics, and data related to machinery usage were identified in preparing of questionnaire.

Collected data were analyzed by using both descriptive and regression analysis methods. Tobit regression model was used to determine the factors affecting the adoption level of tea small holders for machineries. The dependent variable of the model is taken using the following method.

$$\text{Adoption Level} = \frac{\text{Number of Recommended Machineries used by the Tea Small Holder}}{\text{Total Number of Recommended Machineries}} \times 100\%$$

The independent variables used in the model are presented in the following table.

Table 1: Independent variables and their measurements

Variable	Unit of measurement
1.Farming experience (FE)	Years
2. Educational level (EL)	Years
3. Gender (GEN)	Dummy(1= Male, 0= Otherwise)
4. Family labor (FL) usage	Dummy(1= Yes, 0= Otherwise)
5. Hired labor (HL) usage	Dummy(1= Yes, 0= Otherwise)
6. Information gain by TSHDA (ITSHDA)	Dummy(1= Yes, 0= Otherwise)
7. Information received from TRI (ITRI)	Dummy(1= Yes, 0= Otherwise)
8. Age of the farmer (AOF)	Years
9. Owned land (OL)	Dummy(1= Yes, 0= Otherwise)
10. Rented land (RL)	Dummy(1= Yes, 0= Otherwise)
11.Time spending in the tea land per day (TSL)	Hours
12. Age of the cultivation (AOC)	Years
13.Average Educational level of the farmer's family (ELF)	Years
14. Tea green leaf Yield (YLD)	Kilograms

The Tobit model could be written as follows,

$$Y_i = \beta_0 + \beta_i X_i + \varepsilon_i \;\; if\; RHS > 0, 0 = otherwise$$

Where, RHS = Right Hand Side

Y_i – Level of Adoption.
X_i – Vector of independent variables
β_i–Slope coefficient
β_0– Intercept coefficient
ε_i– Random Error term

Finally, we estimated the following form of Tobit Model

$$Y= \beta_0 + \beta_1 FE + \beta_2 EL + \beta_3 GEN + \beta_4 FL + \beta_5 HL + \beta_6 ITSHDA + \beta_7 ITRI + \beta_8 AOF + \beta_9 OL + \beta_{10} RL + \beta_{11} TSL + \beta_{12} AOC + \beta_{13} ELF + \beta_{14} YLD + \varepsilon_i$$

Apart from the Tobit Regression Model, a logistic regression model was alsoestimated to identify the determinants of decision to adopt the machineries by tea small holders in Kalutara District.

$Y_i = \beta_0 + \beta_i X_i + \varepsilon_i$

Y_i is a dichotomous variable indicating

$Y_i = 1$ if at least one machinery was adopted and 0 = otherwise

$$logit\ (p_i) = log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_i X_i + \varepsilon_i$$

The logistic model could be written as follows,

$$log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 FX + \beta_2 EL + \beta_3 GEN + \beta_4 FL + \beta_5 HL + \beta_6 ITSHDA + \beta_7 ITRI + \beta_8 AOF + \beta_9 OL + \beta_{10} RL + \beta_{11} TSL + \beta_{12} AOC + \beta_{13} ELF + \beta_{14} YLD + \varepsilon_i$$

The variables that were used in the model are same as the variables shown in Table 01.

Results and Discussion

This section presents the results of the study and they are discussed where necessary. First we present the descriptive results and then the results of the Tobit and Logistic Regression (Table 2).

Adoption level of tea smallholders

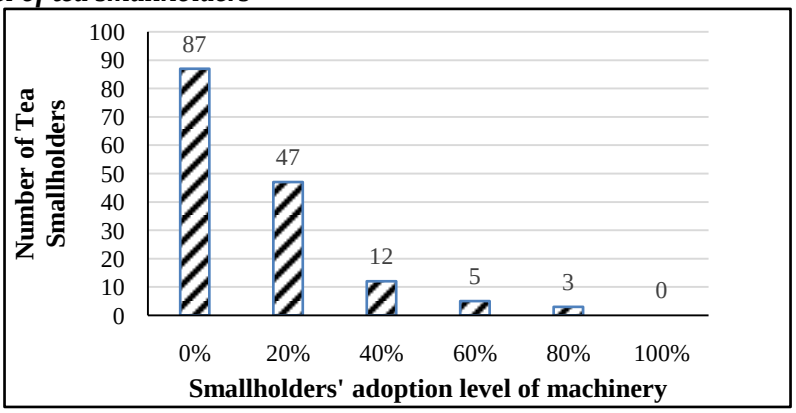

Figure 1: Distribution of tea smallholders according to the adoption level

According to the Figure 1, 87 (56.50%) of tea smallholders have 0% of adoption level i.e. 87 smallholdersdo not use at least one type of machine from 5 types of machineries. 47 smallholders use at least one type of machine while adoption level of 12 tea

smallholdersis 40%. Only 5 smallholdersuse 3 machineries so that their adoption level accounts to 60% while only 3 smallholdersuse 4 machineries accounting to adoption level of 80%. There is not a single smallholderwho uses all the five machineries.

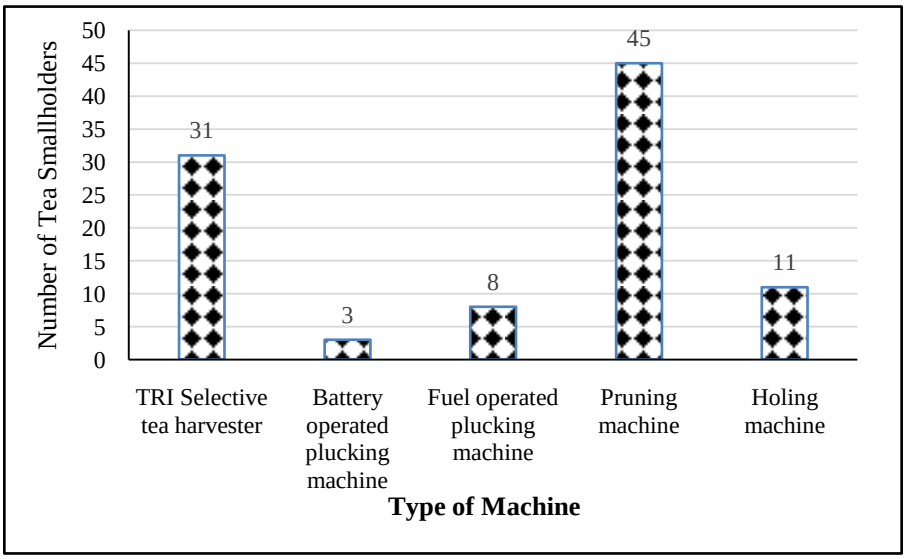

Figure 2: Distribution of tea smallholders according to machinery usage

Machinery usage of the adopted tea smallholders

According to the Figure 2, highest number of tea smallholders (29.22%) use pruning machine. It is a fact that tea harvesting is a costly operation and it accounts for much cost. It is also to a certain extent time consuming. Therefore, TRI has introduced selective harvesting shear. If it is used, it will increase the labor productivity while reducing cost. The present study found that only 20.13% tea smallholders use TRI selective tea harvester. 7.14% tea smallholders use holing machine. Only 5.19% of tea smallholders use fuel operated plucking machine while 1.95% of tea smallholders use battery operated plucking machine.

Tobit Model Estimation

Tobit regression analysis was conducted to satisfy the main objective of the study i.e.to identify the factors affecting to the adoption level of machinery by tea small holders in Kalutara District. The results of Tobit regression model is presented in the Table 2.

The results revealed that the adoption level on machinery is significantly determined by the Farming experience, educational level of the tea smallholder, gender, family labor, information by TRI, age of the famer, owned land, time spending in the tea land and the tea yield. Farming experience, gender, family labor, information by TRI, owned land of the tea small holder are positively related with the adoption level of

machineries. Educational level, age of the farmer, hired labors and time spending in the tea land are negatively related to adoption level.

Table 2: Results of the Tobit and Logistic Regression Models

Variable	Tobit Regression Coefficients	Logistic Regression Coefficients
Farming Experience	1.40 ***	0 .14***
	(2.83)	(3.13)
Educational Level	-2.19 *	-0.10
	(-1.72)	(-0.92)
Gender	21.23 ***	1.63***
	(2.82)	(2.76)
Family Labor	11.58*	1.55**
	(1.68)	(2.50)
Hired Labor	-15.55	-1.33
	(-1.32)	(-1.38)
Information by TSHDA	-3.43	-0.80
	(-0.56)	(-1.51)
Information by TRI	28.96***	1.30
	(2.66)	(1.16)
Age of the Farmer	-1.44***	-0.13
	(-4.01)	(-4.03)
Owned Land	31.94***	1.82 **
	(3.11)	(2.34)
Rented Land	8.33	-0.05
	(0.69)	(-0.06)
Time spending in the tea land	-3.91*	-0.50***
	(-1.77)	(-2.60)
Age of the cultivation	0.82	0.06
	(1.59)	(1.45)
Mean Educational level of the family	0.21	-0.07
	(0.14)	(-0.58)
Yield	0.01**	0.004***
	(2.25)	(3.33)
Constant	28.96	3.24
	(0.91)	(1.18)
Number of Observation	154	154
Model Significance	0.0000	0.0000
Pseudo R^2	0.0829	0.3383

*Statistically significant at ***1 % level, **5 % level,* 10 % level*
t-statistics and z-statistics are in the parenthesis respectively

It is fact that experienced farmers tend to use more machinaries as they understand the importance of increased labor productivity. Most of these machinaries are used by male tea smallholders. Therefore, when there are more males, they tend to use many machinaries. Normally family labor is an implicit cost and it is not accounted in cost

calculations. Smallholders feel that if they use family labour, it is not a cost to them. When they use family labor and machineries, their overall cost could be minimized and productivity also increases which ultimately leads to increase the family income. Therefore, they prefer to adopt machineries with more family members. Extension services play an important role in increasing the productivity and making the smallholders aware of new technologies and machineries. More they use the information provided by extension agent like TRI, more will be the use of machineries in their production process. This is really important in the case of tea cultivation. It is also a fact that young farmers easily embrace the new technologies. Therefore, more young tea smallholders tend to use these technologies. It is also an incentive for tea smallholders to use more machinaries when they own a land as their sole objective is to maximize profit through increase in productivity and minimizing cost. If tea smallholders spend more time on field operations and attending to cultural practices, it implies that they do not tend to use machineries. However, with increase in tea yield they tend to use more machinaries.

Logistic Regression Estimation

Logistic regression was conducted to identify the determinants of decision to adopt by tea small holders in Kalutara District. The result revealed that the adoption of machinery is significantly determined by the farming experience, gender, age of the farmer, time spending in the tea land, yield, family labor and owned land. According to the analysis, there is no significant relationship between adoption and educational level of the farmer, age of the cultivation, educational level of the family members, hired labor, information by TSHDA, Information by TRI and rented land.

Logistic regression results presented in Table 2 suggest that more experienced farmers tend to make the decision to adopt machineries in their production process. So is the case with gender of the tea smallholder, use of family labor in tea production, land ownership and yield of tea. The most important thing in the results is that age of the tea smallholder and the extension services provided by the TRI do not contribute to make decision to adopt machineries. This result provides important implications. For example, tea smallholders adoption rate increases with TRI information but not significant in decision to adopt at the first instant. It is a fact that introduction of a new technology is difficult according to the extension theories. But once it adopted, the others also tend to use it. This may be the reason not to make the decision to adopt but adoption rates goes up when providing information by TRI. Results also suggest that age of the tea smallholder is not significant determinant of adoption decision.

Conclusions

Tea small holders in Kalutara district have 12.73% of overall adoption level on machinery. Among 5 machineries more farmers adopt to use TRI selective harvester and pruning machine. Famers have least adoption level on battery operated plucking machine.Young male tea land owners with sufficient experience in cultivation who uses family labor and extension facilities from Tea Research Institute tend to adopt

machineries. Our results also suggest that they tend to use more machineries if their tea yield is higher. However, more educated tea smallholders do not tend to use machineries while time spent on tea land for management practices also reduces the machinery usage. The decisions to adopt the machineries do not depend on the extension facilities given by the TRI while the tea smallholders who adopted the machineries seek more information. Therefore, it is recommended to improve and strengthen the extension facilities to gain productive gains from the use of machineries.

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EFFICIENCY OF ACTIVATED CARBON PRODUCED FROM POLYETHYLENE TEREPHTHALATE (PET) WASTE MATERIALS FOR THE TREATMENT OF MUNICIPAL SOLID WASTE LANDFILL LEACHATE

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Abstract

Municipal Solid Waste (MSW) is a major growing problem in urban areas of Sri Lanka. Municipal solid waste mainly composed of plastics namely polyethylene terephthalate (PET) waste. Further, percolation of landfill leachate into the groundwater tables and aquifer system, which poses a potential risk and hazardous towards the public health and ecosystem. Therefore, there is a need for the efficient management of PET waste and to treat leachate before discharging into surrounding environment. The objectives of this study were (i) to produce the activated carbon from PET (Polyethylene terephthalate) waste materials (ii) to determine the efficiency of activated carbon for the treatment of MSW landfill leachate. Activated carbon was prepared by carbonization followed by chemical activation with KOH. Leachate was collected from the Koduwamadu MSW landfill Batticaloa. Production rate of activated carbon was obtained as 27.92%. Adsorption experiments were performed in a 250ml of conical flask. 250ml of leachate sample was poured in to 7g of activated carbon in conical flask. The effluent from conical flask was collected at 3rd, 5th, 7th, and 9th day interval and analyzed for different water quality parameters. The initial value of TDS, COD, BOD_5, phosphate, pH and EC were 5846.66±55.76mg/l, 2112.66±2.90mg/l, 360±2.88mg/l, 16.93±0.1mg/l, 8.543±0.072 and 10.3±0.11mS/cm, respectively. The treated samples were collected at 3rd, 5th, 7th and 9th day to measure the above mentioned parameters. In 9th day, the maximum removal of TDS (71.44%), COD (84.66%), BOD_5 (69.16%), phosphate (55.16%) was observed and pH and EC were 7.28±0.2 and 6.49±0.11mS/cm, respectively. Therefore, it revealed that the activated carbon produced from PET waste materials effectively removed the above mentioned parameters from leachate and considered as an efficient medium for the treatment of MSW leachate.

Keywords: Activated carbon, Landfill, Leachate, Municipal solid waste, PET bottles.

Introduction

Solid waste specially Municipal Solid Waste (MSW), is a major growing problem in urban areas of Sri Lanka and this problem arises due to the absence of proper solid waste management system in the country. In many instances solid waste is collected in

mixed state without proper waste separation and dumped in environmentally very sensitive places like road sides, marshy lands, low laying areas, public places, forest and wild life areas, and near to water sources etc. Those will cause numerous negative environmental impacts such as air pollution, soil pollution, ground water and surface water pollution. Also, improper solid waste management reduces the aesthetic value and scenic beauty of the environment and open dumping sites act as ideal places for the breeding of disease vectors like mosquitoes, flies, rats, and rodents.In solid waste, mainly plastic waste namely polyethylene terephthalate (PET) which is most commonly associated with plastic drink bottles, is one of the major problems of our society (Adibfar *et al*., 2017). The current PET consumption rate constitutes a relevant environmentally unsustainable problem due to the huge amount of solid waste produced and to its low bio- and photo degradability. The rate of waste generation in the society is increasing with the increase of population, technical development, and changes of the life style of the people. National Strategy for Solid Waste Management (NSSWM) has shown the importance of focusing on waste avoidance, reduction, reuse, recycling and final disposal in an environmentally sound manner and still giving higher priority for waste recycling over disposal. And also it is very important to separate waste at the source of generation to different components to facilitate subsequent waste management practice, especially recycling. In Sri Lanka, MSW generation per day is around 6400 tons (Madhushan *et al*., 2011) and according to statistics of National Solid Waste Management Support Centre (NSWMSC), 10,497 tons of waste generated per day in the year 2014. In Eastern province, generates 785 tons waste per day (NSWMSC, 2013). Percentage of MSW collection amount is 347 tons per day (NSWMSC, 2013).Water scarcity is another most urgent environmental problem faced in 21st century. Percolation of landfill leachate into the groundwater tables and aquifer system poses a potential risk and potential hazards towards the public health and ecosystem. Production of activated carbon from waste PET bottles is an efficient method for recycling PET bottles (Adibfar *et al*., 2017) as well as treating the MSW landfill leachate. Thus, this study aimed to evaluate the efficiency of activated carbon produced from PET waste materials for the treatment of leachate collected from Koduwamadu MSW landfill.

Materials and Methods

Raw material collection

Polyethylene terephthalate (PET) waste bottles were collected from different areas in Batticaloa. Bottles were washed thoroughly to eliminate the impurities.

Production of Activated Carbon from PET waste bottles by chemical activation

The vertical type cylindrical metal furnace (Length- 20cm and diameter- 3.5cm) was constructed at the department of Agricultural Engineering, Eastern University, Sri Lanka for the purpose of producing activated carbon. The PET bottle wastes were crushed and sieved to obtain desired size fraction (1-3 mm) using conventional sieve-shaker. Then, 20-25g of raw PET was placed in a metal furnace. The furnace was heated to 500˚C under N_2 gas (99.99%) flow pass through the tube and remained in this

temperature for 1.5hours and the system was cooled overnight. 100g of char obtained was soaked in KOH solution at impregnation ratio of 1:1 (W/V) for 24 hours. The mixture was dehydrated in an oven overnight at the temperature of 105˚C. Thereafter, sample was activated at the temperature of 500˚C for 15minutes. The product was cooled to room temperature and washed using distilled water to remove the remaining chemical until the pH become around 6-7. The final product was crushed and sieved to get powdered activated carbon (typical diameter of less than 0.074mm (Metcalf and Eddy, 2003).

Production rate of activated carbon

50g of crushed raw PET waste was used as an input and after the carbonization obtains char (output) was weighted.

Production rate of activated carbon was calculated using following equation:

$$\text{Production rate of activated carbon} = \frac{\text{Amount of activated carbon obtained (g)}}{\text{Amount of raw PET waste used (g)}} * 100$$

Landfill leachate collection and Analysis

Leachate samples were collected from koduwamadu Municipal solid waste landfill in Batticaloa and analyzed for the water quality parameters of TDS, COD, BOD_5, phosphate pH, and EC. Collected samples were analyzed by standard methods and equipments as given in Table 1. Laboratory analysis was conducted at the Department of Agricultural Engineering, Faculty of Agriculture, Eastern University, Sri Lanka.

Table 1: Methods/instrument to analyze chemical and physical properties of leachate

Parameters	Method/ Instrument
pH	Portable pH meter (Model-EUTEC pH-700)
Electrical Conductivity	Portable pH meter (Model-EUTEC pH-700)
Total Dissolved Solid (TDS)	Oven dry method
Chemical oxygen demand (COD)	Back titration method
Biochemical oxygen demand (BOD)	Electrometric method
Phosphate	Spectrophotometric method (Model – Genesis 10S UV-Vis)

Treatment of landfill leachate by activated carbon and effluent analysis

Adsorption experiments were performed in a 250ml of conical flask. 250ml of leachate sample was poured in to 7g of activated carbon in a conical flask. The effluent from conical flask was collected at 3rd, 5th, 7th, and 9th day interval and analyzed for different water quality parameters. The experiment was laid out in a complete randomized design (CRD). There were four treatments (T1- 3rd, T2-5th, T3-7th, T4-9th day) based on the retention time and each treatment has three replicates. The data were statistically analyzed by SAS software (SAS version 9.1.3).

Result and Discussion

Production rate of activated carbon

Amount of raw PET waste used (input) = 50g
Amount of activated carbon obtained (output) = 13.96g

$$\text{Production rate of activated carbon} = \frac{\text{Amount of activated carbon obtained (g)}}{\text{Amount of raw PET waste used (g)}} * 100$$

$$= \frac{13.96\text{g}}{50\text{g}} * 100$$

$$= 27.92\%$$

Leachate quality

Table 2: Changes of MSW landfill leachate quality parameters with retention time

Parameters	Initial	3rd Day	5th Day	7th Day	9th day
pH	8.543±0.072	7.84±0.03	7.52±0.02	7.44±0.03	7.28±0.2
TDS (mg/l)	5846.66±55.76	5122.66±31.18	3637.2±23.31	2473.1±3.04	1669±65.54
BOD (mg/l)^5	360±2.88	282±8.386	172.66±4.05	133.66±3.38	111.67±2.72
COD (mg/l)	2112.66±2.90	1536±18.475	954.667±3.528	567.33±11.795	339.33±9.821
Phosphate (mg/l)	16.93±0.1	13.86±0.07	11.54±0.19	9.21±0.05	7.59±0.22
EC (mS/cm)	10.3±0.11	9.09±0.06	8.04±0.22	7.28±0.09	6.49±0.11

Values are means ± standard error of replicate determination.

Table 2 shows the changes of MSW landfill leachate's quality parameters with retention time from initial to 9th day. All the tested parameters showed significant reduction from initial value to 9th day.

Total dissolved solids (TDS)

Initial and final TDS present in the leachate were 5846.66±55.82mg/l and 1669±65.54mg/l respectively. The removal efficiency was 12.38%, 37.79%, 57.70%, and 71.44% at 3rd, 5th, 7th, and 9th day, respectively. Removal of TDS was achieved by ion-exchange. CEA permissible level of TDS in treated wastewater to be discharged into inland water bodies is 2100mg/l. In this activated carbon treatment, the treated leachate had the TDS about 1669±65.54mg/l. Thus, the activated carbon treatment for TDS removal is considered as an efficient method.

Chemical oxygen demand (COD)

The initial COD of landfill leachate was 2112.66mg/l. The measured value was considerably higher than the standard limit (CEA permissible level of COD in treated wastewater to be discharged into inland water bodies is 250mg/l). COD reduction with retention time is given in Table 2. COD was reduced to 1536±18.475mg/l, 954.667±3.528mg/l, 567.33±11.795mg/l, 339.33±9.821mg/l at 3rd, 5th, 7th and 9th day, respectively. In 9th day, percentage of COD removal was 84.66% but the amount of COD in treated leachate in 9th day was higher than the CEA permissible level. In 3rd day, the COD removal was 30.58% and the removal efficiency increased with retention time but the rate of removal was decreased. It was mainly due to an accumulation of non-biodegradable organic compounds present in the system (Aghamohammadi *et al*., 2007).

Biochemical oxygen demand (BOD_5)

BOD is the measure of biodegradable organic mass of leachate and that indicates the maturity of the landfill which typically decreases with time (Qasim and Chaiang, 1994). Initial value of BOD of leachate was 360±2.887mg/l and in 9th day, it was reduced to 111.67±2.72mg/l. In 9th day, the BOD removal was attained to 69.16%. In this study, the maximum rate of BOD removal achieved at 5th day was 52.22%. Following days, the BOD removal increased but the rate of removal was decreased. Lavrova and Koumanova (2013) also reported that the elimination of BOD occurs fast in most cases during the initial six days.

Phosphate

In nature, phosphorus usually exists as part of a phosphate molecule (PO_4^{3-}) (APHA, 1992). The initial phosphate of leachate was 16.93±0.1mg/l. Phosphate was reduced to 13.86±0.07mg/l and 7.59±0.22mg/l in 3rd and 9th day (Table: 2). In 9th day, phosphate removal was attained to 55.16%. Uygur and Kargi (2004) indicated that the leachate phosphate removal by commercial activated carbon is achieved 44%. It showed that our prepared activated carbon exhibited better performance than commercial activated carbon. In 9th day, phosphate in the treated effluent was 7.59±0.22mg/l, but it was more than the standard limits of CEA (CEA permissible level of phosphate in treated wastewater to be discharged into inland water bodies is 5mg/l.)

pH

Leachate is generally found to have pH between 4.5 and 9 (Christensen *et al*., 2001). The mean initial pH was 8.54±0.07, it indicated that the landfill is in the methanogenic phase. During this phase characteristic pH value of leachate is close to 8 (Granet *et al*., 1986). The changes in pH with retention time were clearly shown in the Table: 2. pH of effluent at 9th day became closer to the neutral value. Treatment of activated carbon showed significant reduction in pH (7.28±0.2). The pH of effluent from activated carbon treatment met the CEA standards of maximum permissible limit (6.5-8.5).

Electrical Conductivity (EC)

Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water (Wetzel, 2001). These conductive ions come from dissolved salts and inorganic materials such as alkalis,

chlorides, sulfides and carbonate compounds (Langland and Cronin, 2003). The initial EC of leachate sample was 10.3mS/cm and final was 6.49mS/cm in 9th day. Conductivity is generally influenced by the total amount of dissolved organic and inorganic materials present in the solution, and is used to demonstrate the degree of salinity and mineral contents of leachate (Naveen *et al*., 2014).

Conclusions

The results of the study showed that the activated carbon produced from PET waste materials have an ability to treat landfill leachate. Production rate of activated carbon was obtained as 27.92%. The initial mean values of leachate during this study period were 8.543±0.072, 846.66±55.76mg/l, 360±2.88mg/l, 2112.66±2.90mg/l, 16.93±0.1mg/l and 10.3±0.11mS/cm for pH, TDS, BOD_5, COD, phosphate and EC, respectively. In 9th day, the maximum removal of TDS (71.44%), COD (84.66%), BOD_5 (69.16%), phosphate (55.16%) was achieved and changes in pH and EC were 7.28±0.2 and 6.49±0.11mS/cm, respectively. The activated carbon treatment exhibited more efficient in the removal of TDS, COD and pH from the MSW landfill leachate. However, COD, BOD_5, phosphate, EC were higher than maximum permissible limits of CEA standard for safe discharge wastewater into inland water bodies. Finally, it is concluded that activated carbon is an efficient material for the removal of TDS, COD and pH from the leachate compare to other parameters which were investigated.

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ASSESSMENT OF PALMYRAH PALM DISTRIBUTION AND DENSITY IN EAST AND SOUTH EAST OF VALIKAMAM REGION IN JAFFNA PENINSULA USING VERY HIGH RESOLUTION SATELLITE IMAGES

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Abstract

Palmyrah palms are considered very valuable plant species because of its ecological and economic values derived by environment and people in Jaffna region. It is clearly witnessed that the number and distribution of palmyrah plants have been declining due to destructions of the plants for various purposes. There are no reliable and up to date data on the number, density and distribution of palmyrah plants in the region which are essential for conservation, management and development of palmyrah plants. Conventional methods of counting the plants have many shortcomings and new methods are experimented to inventorize the plants. This research has been undertaken to inventorize the number and distribution of plants using visual interpretation of high resolution Quickbird satellite images of *Valikamam* East Region of Jaffna Peninsula. The images used have multispectral resolution of 2.4 meters and panchromatic resolution of 0.6 meters. Image enhancement techniques were used to improve the lucidness of the image for visual image interpretation using Erdas Imagine 14 image processing software. ArcMap 10.4 version was used to digitize the distribution of plants from the image. *Uduvil*, *Kopay*, *Nallur* and *Jaffna* DS divisions were mapped out for density and distribution of the plants. The data on number of plants which is 49, 746 were derived directly from the digitized data table and the densities of the plants were calculated using geometric calculator functions in ArcMap. According to the analysis, *Kopay* division had higher number of plants and Jaffna DS division has lower number of plants. The *Kopay* Division has higher number of plants which is 20,800 in 9790 hectares. The *Kopay* South GN Division has higher density of plants which is 1831. In *Uduvil* Division, there are 17,676 plants in 2131 hectares and *Erlalai* Division has higher density of plants which is 1925. *Nallur* division has 10,243 plants in 3441 hectares and *Ariyalai* GN Division has higher density of plants which is 6542. Jaffna DS division has lower number of plants in the study area which is 1027 and *Small Bazaar* GN Division has 331 plants. This method of visual interpretation had few shortcomings of time and confusion in the identification of the canopy of palmyrah plants. Numbers of random locations were clarified from ground samples to verify the accuracy of the classification which has proved that the mapping was 99% accurate. This method of inventory consumed more time and few plants were not mapped due to the indiscriminate nature of green vegetation cover. There are object based image

classification methods which can be used to classify the high resolution satellite images for object identification.

Keywords: Palmyrah Palm, Remote Sensing, High Resolution Images, Visual Classification

Introduction

Palmyrah plants in Jaffna Peninsula and other parts of the North and Eastern Provinces of Sri Lanka which entail greater ecological and economic values to the environment and the society, have been threatened due to the prolonged war and unplanned development. Palmyra palm known as *Borassus flabellifer* botanically, is a tropical plant type grow in arid and marginal lands without cultivation or irrigation, is an important component of the environment in the region that enrich the environment and economy. The plants do not require irrigation, manure and protection. Palmyra palm creates substantial extent of green cover and provides ecosystem services in Jaffna Peninsula. The palm generates direct and indirect economic opportunities for people in the region. It was roughly estimated that there were 7 million plants in 1980s in nearly 40,000 hectares of lands, out of which substantial numbers of plants have been fell down and the current distribution is unknown.

Field observation shows that the density and distribution have been declined in various parts of Jaffna Peninsula. The global conditions of environmental vulnerabilities are the cumulative outcome of local events like these in Jaffna and other areas. Environmental resources in Jaffna have played an important role to create economic opportunities and in recent times, the losses of the plant vegetation have deprived the economic potentials for development. The economic and environmental revival requires local action. Since Jaffna Peninsula consist of larger areas of marginal lands combined with water scarcity, palmyra palms are very suitable plant types that can be planted and it will help to improve the environmental quality. Planning, management and development of palmyra plants in Jaffna require data on the distribution and density of palmyra plants.

The public policy and institutional capacities concerned with environmental conservation and management, there is no any consolidated efforts to gather data and take measures to revive the resources of palmyra plants. Since the conventional methods of collecting data about plants require larger amount of financial and human resources with substantial time span. Space based remote sensing techniques provide very cost effective and accurate methods to count the palmyra plants and gather data on the distribution and density of palmyra plant vegetation. Very high resolution satellite images of the study area acquired by Quickbird satellite in 2016. This study was conducted by three researchers covering four Divisional Secretariat Divisions of 16,438 hectares; namely Uduvul, Kopay, Nallur and Jaffna, divided into 129 Grama Niladhari Divisions. The research was conducted from February to July in 2017. 16 random samples were selected from the map and they were checked on the ground for accuracy which conformed to 99.22% to the ground situation.

Research Problem

Distribution and density of palmyra plants have environmental, economic and social implications at local, regional, national and global level. Palmyra plants play a pivotal role in the local and regional contexts of Jaffna peninsula improving the ecosystem and economic system more resilient. The plants are part of the system that creates the ecosystem of the region and they are very valuable resources. The plants have been fell down for various purposes and destroyed during the war in the region. There are no proper replantation schemes to replace loses. Larger number of people depends on economical and material needs on the plants. There is no any clue about the number and distribution of palmyra plants in the region since no any enumeration was undertaken in this regard. The palmyra plant resources must be improved in order to promote the economy of the region. Development of palmyra resources requires the data and information on the distribution and density of palmyra plants. There is no any institution in the region that has any of these data that can be used for decisions related to the management of the plants. There should be a system to manage the palmyra plants which require data and information about the plants. Conventional methods of enumeration have many inconveniences and short comings. Conventional methods of inventorizing the plants will require longer period of time, larger number of enumerators and huge financial resources. An effective method of enumeration was required with higher accuracy and low cost which is where the satellite images have played a role for inventorizing the plants.

Research Objectives

This research has been undertaken to complete the following objectives related to palmyra plants in the 4 Divisional Secretariat Divisions in Jaffna. The objectives are;

- To map out the distribution of Palmyra plants in Uduvil, Kopay, Nallur and Jaffna DS Divisions using high resolution satellite images
- To assess the density of Palmyra plants in the above DS Divisions

Research Methodology

This research began with reviewing researches conducted in the region relevant to palmyra plants and researches done in foreign countries. There were researches carried out in the region and 15 researches conducted in foreign countries were reviewed to critically assesse the research gap and devise methods for this research.

Data and specification

There are sophisticated methods and techniques available for collecting data about different vegetation. For this research, high resolution satellite images have been used to extract information on distribution of palmyra plants. There are satellite images with different resolutions which are useful for various contexts and uses. Images from Quick bird satellite were acquired for this purpose in multi spectral and panchromatic bands.

The multispectral bands are in 2.4 meters spatial resolution and panchromatic band is in 0.6 meters resolution.

Data processing

The images were processed to enhance their visual interpretability for extracting palmyra plants. Since the features in both bands have advantages and disadvantages as multi spectral bands have aspects in natural colors and relatively poor quality features compare to pan images whereas pan images are in black and white but show the spatial features clearly. Therefore, in order to get the benefit of both bands, they were merged together to derive a new images with the resolution of panchromatic images and multi spectral colors. Thereafter, the images were enhanced to improve the distinction between palmyra plants and other vegetation. ERDAS v14 was used to process the images. Table 1 below shows the Specification of Quickbird Images

Table: 1 Sensor Resolution and Spectral Bands of Quickbird Satellite

	Panchromatic	**Multispectral**
Resolution	0.61 Meters	2.44 Meters
Bands	405 – 1053 nm	Blue 430 – 545 nm
		Green 466 – 620 nm
		Red 590 – 710
		NIR 715 – 918
Dynamic Range		11 Bits per pixel
Swath Width		18 Kms

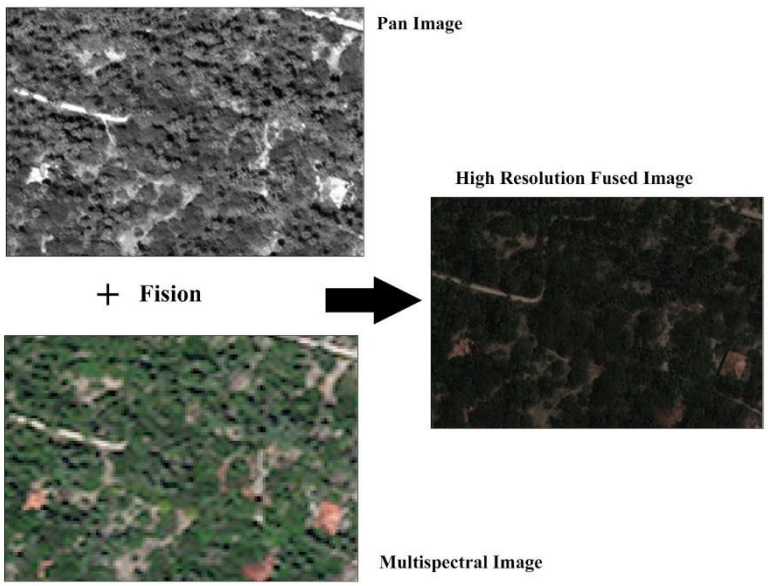

Figure 1: Image Fusion- Panchromatic (0.65cm) + Multispectral (2.4 m)

There are mainly two methods used to extract information; visual interpretation and digital interpretation. This research has employed the visual interpretation methods

Visual Interpretation and Data collection

The palmyra plants were extracted through visual image interpretation using ArcMap software. The images of the respective DS divisions were carefully inspected manually and palmyra plants were traced using digitizing tools embedded in ArcMap software. All plants in the four DS Divisions were digitized and collected in shapefile format. Location of every plant and a attribute table for the plant was developed in the process. Distribution of palmyra plants were in each DS Division was worked out by overlaying GN Division Maps on the palmyra plant layer. The points that fall within the GN Divisions were calculated and obtained as the number of plants in that particular GN Division. The density of palmyra plants were calculated using the plant layer and GN Division data. The numbers of palmyra plants were divided by the extent of each GN Division. This density was calculated using the arithmetic operator facilities available in the attribute data of the plant layer.

Results and discussion

Distribution and density of palmyra plants in four DS Divisions; *Uduvil*, *Kopay*, Jaffna, *Nallur* were obtained from the above analysis of satellite images. The following data extracted from the images show the distribution and density of the plants in the respective divisions.

Palmyra Palm Distribution in Uduvil DS Division

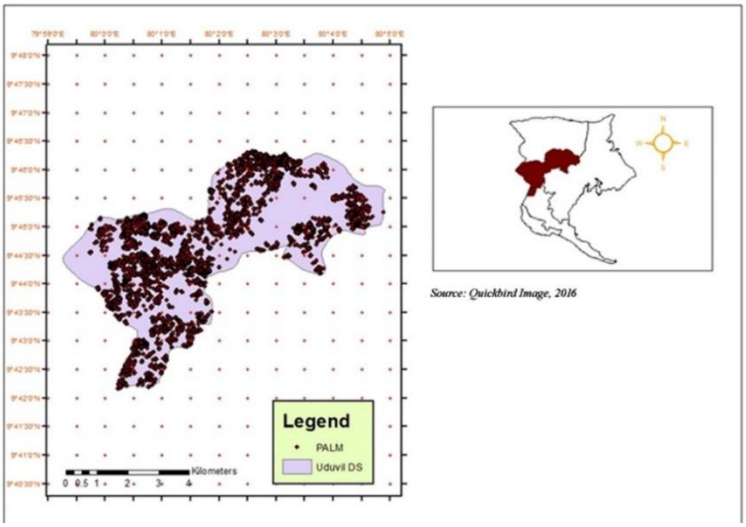

Figure 2: Distribution of Palmyra plants in Uduvil DS division in Jaffna- 2016

There are 17,676 plants in 2131 hectares of land covered by 30 GN Divisions. Highest numbers of plants of 1925 exist in *Erlalai* North GN Division and lowest number 20

exist in *Chunakam* South GN Division. Highest density in the Division, 22 plants per hectare found in *Kuppilan* North GN Division. The following GN Division has less than 500 plants; *Uduvil* South East, South West, Centre, *Sanguveli*, *Innuvil* West, North East, West, *Chunakam* Town North, Town Centre, *Thavady* East, North and *Erlalai* South West. The following GN Divisions have plants between 501 to 1000 in each GN Division; *Thavadi* South, *Chunakam* Town East, West, Erlalai West, South, East, Centre, *Evenai* and *Kuppulan* North. The following GN Divisions have more than 1001 plants in each division; *Chunakam* Town South, *Kankesanthurai*, *Erlalai* North, *Punnalaikaduvan* South, North, *Kuppilan* South, *Uduvil* Centre North, North

Palmyra Palm Distribution in Kopay DS Division

There are 20800 plants found in 9790 hectares of land covered by 31 GN Divisions. Highest number of plants found in *Kopay* South GN Division and lowest number of plants, 75 found in *Urumpirai* East GN Division. The following each GN Division has less than 500 palmyra plants; *AchchuvelyAchchuvely* North, South, West, *Avarankal* West, *Idaikadu*, *Kalviyan Kaadu* West, *Pathameny*, *Puttur* North, West, *Urelu*, *Urumpirai* East, North, South, West and *Valalai*. The following GN Divisions each have 501 to 1000 plants; *Avaranakaal* East, *Kopay* North, *Neervely* West, *Puttur* East, *Thampalai* and *Kathiripai*.

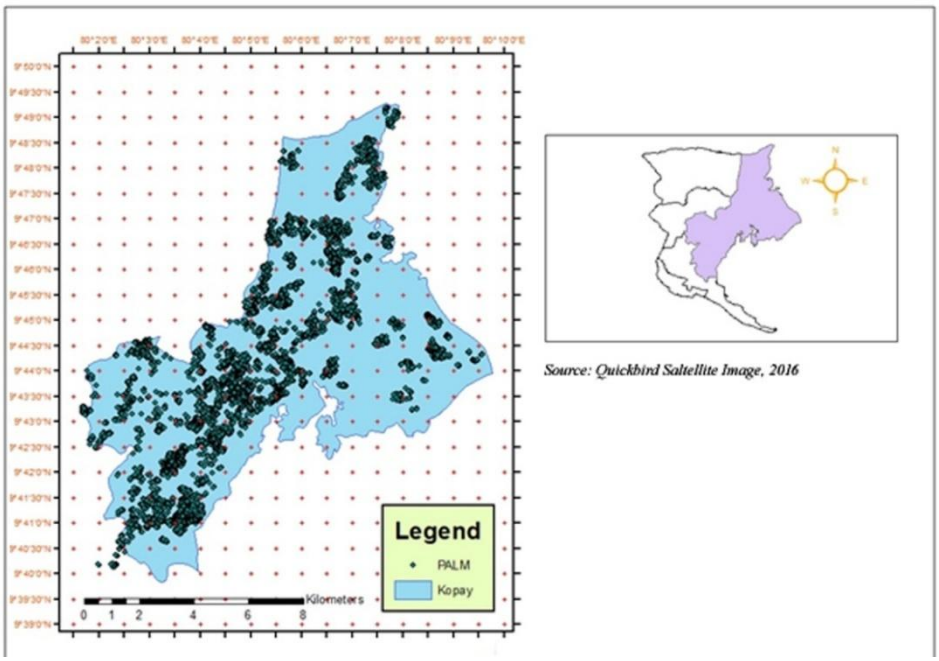

Figure 3: Distribution of Palmyra plants in Kopay DS division in 2016

The following GN Divisions each have more than 1000 plants; *Irupalai* East, South, *Kopay* Centre, South, *Nawakiri*, *Neervely* North, South, *Sirupity* East, West and *Vatharawathai*.

Palmyra Palm Distribution in Nallur DS Division

There are 10,243 plants found in 3441 hectares of lands in 40 GN Divisions. Highest number of plants found in *Ariyalai* South East and lowest number found in *Kantharmadam* North East. The following GN Divisions have each less than 100 plants; *Ariyalai* Centre, North, Centre South, South West, South East, *Kokuvil* North West, Centre East, North West, *Nallur* Centre, East, North, *Thirunelvely* Centre North, Centre South, North East, South East, *Vannarpannai* North East, North, South East, North West. The following GN Divisions have plants between 100 to 500; *Ariyalai* Centre North, Centre South, South West, *Kokuvil* Centre West, Centre East, *Kondavil* Centre West, North East, South East, South West, *Nallur* South and *Thirunelvely* West. *Ariyalai* South East has more than 500 plants.

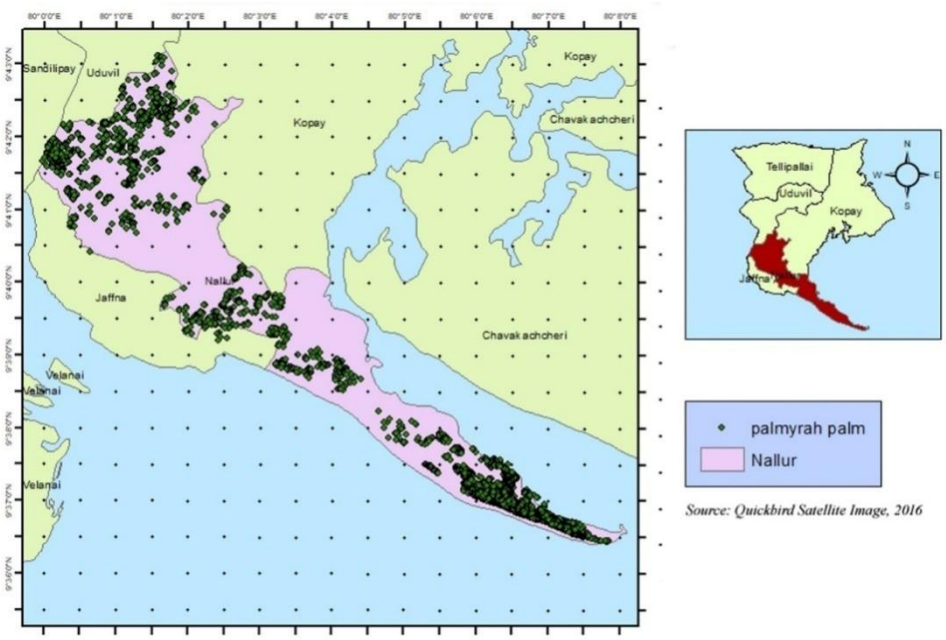

Figure 4: Distribution of Palmyra plants in Nallur DS division -2016

Palmyra Palm Distribution in Jaffna Division

There are 1027 plants in 1068 hectares of land covered by 28 GN Divisions. Highest number of plants, 331 found in Small Bazaar and lowest number of 3 found in New Moor Street division.

Table 2: Distribution of Palmyrah Plants in the Study area

Level of Distribution	Number of Plants	Number of GN Divisions
Very Low	< 400	90
Low	401 – 800	18
Medium	801 – 1200	10
High	1201 – 1600	07
Very High	> 1600	04

Table: 3 Density of Palmyrah Plants in the Study Area
(Number of Plants per Hectare)

Level of Density	Number of Plants	Number of Divisions
Very Low	0 – 2	79
Low	3 – 4	23
Medium	5 – 7	18
High	8 – 10	08
Very High	> 10	01

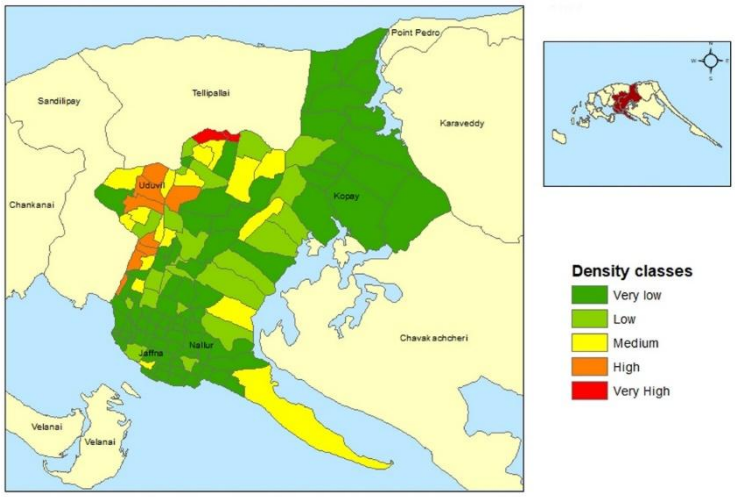

Figure 5: Density of Palmyra plants in East and South East of Valikaamam Region 2016 (Source: Quickbird Satellite Image, 2016)

Accuracy Assessment

Analysis and data extraction from remotely sensed images require ground verification to verify its accuracy. Randomly selected 16 patches from the map were used for ground verification. The corner coordinates of each isolated patches were used to find

the location of those plants on the ground. GPS embedded in mobile phone was used to find the location of those patches. The number of plants in a patch were compared with the number of plants in the corresponding patch on the ground.

The following table 4 show the verification of accuracy of mapping.

Table 4: Accuracy Assessment Table

Sample area	Area(ha)	CENTEROIDS X	CENTEROIDS Y	Field count	map count	Accuracy
A1	1	116875.51	496522.642	54	54	100
A2	1	118356.029	499097.427	82	81	97.59
A3	1	121110.725	496848.642	61	61	100
A4	1	122628.502	499715.716	43	43	100
A5	1	113670.041	502092.12	52	51	98.08
A6	1	121896.311	503433.331	27	27	100
A7	1			6	6	100
A8	1			32	32	100
A9	1	121976.298	496522.642	16	16	100
A10	1	122306.247	496848.054	32	32	100
A11	1	122062.963	497383.042	79	78	98.73
A12	1	123773.299	501274.724	137	133	97.08
A13	1	123802.439	501718.828	76	76	98.7
A14	1	124798.399	503685.85	73	73	100
A15	1	118358.383	501266.217	146	142	97.26
A16	1	116319.143	499097.427	54	54	100
						99.215

Conclusion and Recommendations

This study shows that the use of remotely sensed images is very useful and accurate for palmyra plant mapping. There are 49,746 plants have been identified from the images of four DS Divisions. There are 20,800 plants in *Kopay* Division, 17,676 plants in *Uduvil* Division, 10243 plants in *Nallur* Division and 1027 plants in Jaffna Division. Highest number of plants exist in *Ariyalai* South East GN Division in *Nallur* DS Area and higher plant density in *Kuppulan* GN Division in the *Uduvil* DS area. The study shows that the average density of plants in four DS Divisions are as follows; in *Uduvul*, 8 plants per hectare, in *Nallur*, 3 Plants per hectare, in *Kopay*, 2 plants per hectare, in Jaffna, 1 plant per hectare. Jaffna division consist of lower number of plants due to the level of urbanization. The images based mapping is very efficient in the areas where the density is low. In higher density areas, the canopy of the plants are interwoven and was difficult to identify separately. Certain areas in *Uduvil* were cover with mist and were difficult to clearly identify the plant canopy. The plants in different ages, young and middle and older age could not be separately identified. It is obviously seen that in the North of *Uduvil* DS area, larger number of plants have been cut down for military purposes.

The mapping based on very high resolution satellite images must be extended to other areas of the peninsula and other parts of the country. There are very high resolution images than Quickbird images such as Worldview 3 and Worldview 4 which have 30 centimeter panchromatic resolutions. In it easier and more precise to demarcate palmyra plants from Worldview images. Another recommendation is that the object based image analysis software such as eCognition can be used to identify the palmyra plant areas more accurately. The manual identification in this method take relatively more time to complete. Object based Image Analysis software will automatically detect and create map data. Drone mapping also is recommended because of the minimized cost. This drone mapping can be continued to other areas with the initial and operating cost.

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SPATIAL VARIATION OF WATER QUALITY OF THE UNNICHCHAI RIGHT BANK CANAL IN BATTICALOA DISTRICT

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Abstract

Over the past decades, quality of irrigation water has become a serious issue faced by the agricultural sector all over the world. Poor quality of irrigation water adversely affects both soil quality and crop production. Hence, irrigating the crops with good quality water is vital to get optimum crop yield without affecting soil quality. Unnichchai is one of the major irrigation systems in Batticaloa district. Great spatial and temporal variations in paddy yield were observed in this system. Among several factors, quality of irrigation water has great influence on crop yield. In the above context, the present study aimed at assessing the suitability of Right Bank (RB) canal water of Unnichchai irrigation system for irrigation purpose. Water samples were taken at 1 km interval along the RB canal during cultivation and harvesting periods in *Yala* season and analyzed for some important quality parameters. It was found that the quality of RB canal water varies along the canal. Seasonal variation was also observed and the variation was significant at some places. The pH of canal water varied from 6.72-7.55 indicating slightly acidic in nature. The range of Electric Conductivity (EC), Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and PO_4^{3-} was lower than the maximum acceptable limit for irrigation purpose. In addition, the derived quality parameters such as RSC, SAR and SSP were varied from 0.048 me/l to 0.48 me/l, 0.07 to 1.48 and 8.8% to 46.2%, respectively. The Ca^{2+}/Mg^{2+} ratio of samples was found as more than one. It was observed that the level of these quality parameters was more or less constant up to 15 km from the tank and thereafter increased substantially and reached the maximum level at tail end. In overall, RB canal water is safe for irrigation in *Yala* season. However, appropriate management intervention must be implemented to avoid further deterioration of canal water especially 15 km from tank to the canal distance up to tail end.

Keywords: Irrigation, Unnichchai irrigation scheme, Water quality

Introduction

Supply of good quality irrigation water is critical to obtain optimum crop yield while maintaining soil fertility, ecological balance and human health. Poor quality of irrigation water adversely affects both soil quality and crop production (Bello, 2001). Therefore, ensuring water quality in an irrigation system is vital to ensure the sustainable yield. In the dry season, high nutrient enrichment cause eutrophication

which affects the quality of water in water bodies especially in dams, canals, or slow flowing shallow rivers.

Soluble salts are the major factor to determine the irrigation water quality. The concentration and proportion of these dissolved ions determine the suitability of water for irrigation purpose (Ajayi *et al*., 1990). The amount and characteristics of these dissolved salts depend on the source and chemical composition. The most ordinarily dissolved ions in water are sodium (Na^{+}), magnesium (Mg^{2+}), calcium (Ca^{2+}), sulphate (SO_4^{2+}), nitrate (NO_3^{2-}), chloride (Cl^{-}), carbonate (CO_3^{2-}) and bicarbonate (HCO_3^{-})and their concentration may change the salt concentration. There are three major types of irrigation water quality related problems which are salinity, solidity and toxicities. Use of problematic water for irrigation deteriorates soil properties (Ghafoor *et al*., 1997; Qureshi and Masih, 2002), and reduces crop yields.

Unnichchai is one of the major irrigation systems in Batticaloa district. It supplies irrigation water through left bank (LB) and right bank (RB) canals. This canal water is being polluted by number of pollution sources. Animal wastes and agricultural runoff directly reach irrigation canals as most of the paddy outlets are diverted into Unnichchai irrigation canals. Further, excessive use of fertilizers has the potential of being leached or washed into the canal. However, there is lack of information on the quality of canal water in this irrigation system. In this view, the present study aimed at assessing the quality of RB canal water and ascertaining its suitability for irrigation purpose.

Materials and Methods

Description of study area

Unnichchai tank is one of the major irrigation tanks located at Unnichchai village of Batticaloa district. The latitude and longitude of the tank are 7^{o} 37' N and 81^{o} 33' E, respectively. It supplies water through both RB and LB canals mainly for irrigation purpose. The length of the RB and LB canals are 23 km and 13.2 km, respectively. According to the Divisional Irrigation Engineer's Office, Rugam- Chenkalady (2018), the RB canal supplies water to the command area of 3691 acres whilst LB canal supplies water to the command of 4495 acres. This tank receives runoff water from the catchment which is covered with thick jungle and grassland.

Sampling

In the present study, RB canal of Unnichchai irrigation system was selected. Canal water samples were collected at 1 km interval starting from tank to tail end during cultivation and harvesting periods in *Yala* season. Prior to water sampling, the sampling bottles (one liter plastic bottles) were cleaned and rinsed with distilled water. Those were then rinsed three times with the canal water at the time of sampling. Water samples were collected at the mid-stream at the depth of 15-20 cm from the surface. Figure 1 shows location of Unnichchai tank and sampling locations along the RB canal.

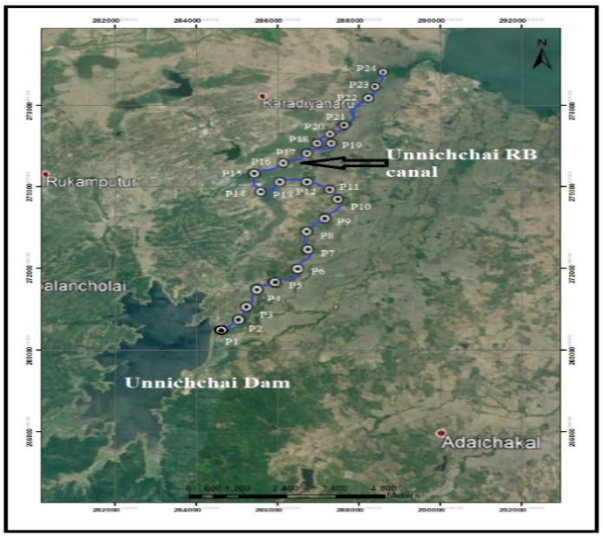

Figure 1: Location of the Unnichchai tank and sampling points

Analysis of samples

Water quality parameters such as pH, EC, and TDS were measured at the field soon after collecting samples using digital pH /EC /TDS Meter (model HI 98130).Calcium was analyzed by complexometric titration method using 10% of NaOH and Calcon as an indicator. Total Ca^{2+} and Mg^{2+} concentration were determined using NH_4Cl and NH_4OH as a buffer and Eric Chrome Black T (EBT) as an indicator. From which the Magnesium concentration was found by subtracting from the total concentration of Ca and Mg (USDA Handbook 60). Carbonate and bicarbonate were analyzed by titration (USDA Handbook 60). Sodium and potassium were analyzed by flame photo meter using standard solution of $NaNO_3$ and KNO_3. Total Solid (TS) and TSS concentrations were determined by oven dry method. The phosphate concentration was measured using UV visible spectrophotometer. In addition, the derived parameters such as calcium magnesium ratio, Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR) and Soluble Sodium Percentage (SSP) were determined using the following equations (Richards, 1954) for assessing the suitability of water for irrigation purpose.

1. $RSC = [(CO_3^{2-}+HCO_3^{-}) - (Ca^{2+} + Mg^{2+})]$
2. $$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$
3. $$SSP = \frac{Na^+}{Na^+ + Ca^{2+} + Mg^{2+} + K^+} X100$$
4. Calcium Magnesium ratio = Ca^{2+}/Mg^{2+}

Where the concentrations of each ion is expressed in $meqL^{-1}$

Data Analysis

Data analysis was performed using MS Excel 2010 and SPSS Statistical package version 22.0.

Results and Discussion

pH

The pH of canal water ranged from 6.62-7.55 (mean value 6.9 ± 0.26) and 6.62 to 7.5 (mean value of 6.89 ± 0.22) during cultivation and harvesting period, respectively, indicating that the water in the canal is slightly acidic in nature (Figure 2). The maximum pH value of 7.55 was observed at the tail end whereas the lowest pH value of 6.72 was observed at 10 km distance from the tank during cultivation period. The corresponding values measured during harvesting period were 7.5 (at tail end) and 6.62 at 10 km from the tank. The pH value was almost constant up to 20 km during both periods. However, a substantial increase in pH was observed from 20 km onwards. This variation might be due to the land use pattern and the geology of the surrounding area. During cultivation period, water from the paddy fields drains into the canal through number of outlets which is containg nutrient rich water. Using chi- Square test the pH value show the significant difference (p=0.001) and (p=0.016) during cultivation and harvesting period. The pH was positively correlated with the canal distance the results are consistent with previous study conducted by Adeniyi and Mbagwu (1990). Further, pH level of RB canal water during both periods falls within the acceptable range of 6.5-8.5 (WHO 2004).

Electrical Conductivity (EC)

EC is viewed as a valuable indicator of the amount of dissolved materials in water. The canal water EC ranged from 0.02 - 0.51 (mean value 0.1196 ± 0.16 dS m^{-1}) and 0.02-0.45 dSm^{-1} (mean value 0.0958 ± 0.13 dS m^{-1}) and EC shows significant different (p=0.00) and (P=0.001) during cultivation and harvesting period, respectively (Figure 2). Maximum value of EC was observed at the tail end whereas the minimum value was recorded at the Unnichchai tank (0 km) during both periods. The EC level of RB canal water was more or less constant up to 15 km, and thereafter it has increased. Further, the EC level was higher during the cultivation period than harvesting period. It was observed that the elevation of canal bank up to 15 km from the tank is higher than the paddy fields. Therefore, direct discharge from the paddy fields into the canal is not possible. Nevertheless, number of discharge points draining water from paddy fields into the canal was observed in the downstream. This might be the reason for the increase in EC level in the downstream. Leaching of dissolved solids from the agricultural area near to the RB canal may also influence on EC level. Both period of sampling, Table 1 shows suitability classification of irrigation water based on EC values. Accordingly, canal water up to 17 km from the tank falls under low salinity class while from 17 km to 22 km it falls under medium salinity class during cultivation period. The water at the tail end exceeded the EC level of 0.5 dSm^{-1} and thus not suitable for irrigation. However, all samples collected during harvesting period were within the maximum EC level of 0.5 dSm^{-1}.

Table 1: Suitability classification of irrigation water based on EC values (Richards, 1954)

Water class	EC (dSm^{-1})	Remarks
Low salinity	< 0.16	Can be used safely
Medium salinity	0.16 – 0.5	Can be used with moderate leaching
High salinity	0.5 - 1.5	Cannot be used for irrigation
very high salinity	1.5 – 30	Purposes

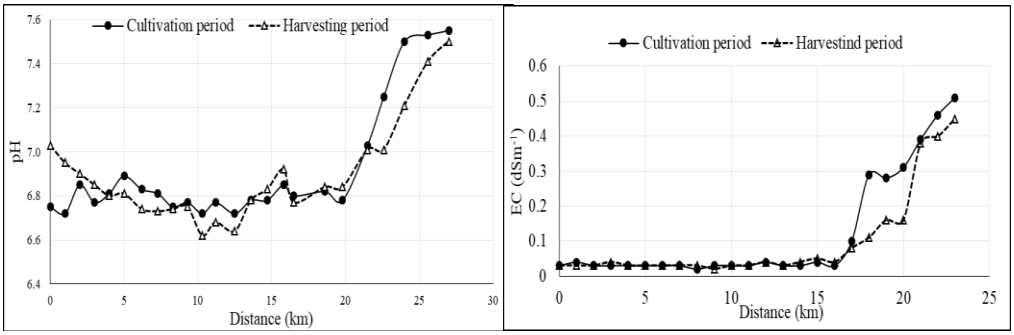

Figure 2: Variation of water quality parameters such aspH and EC during cultivation and harvesting periods in RB canal of Unnichchai irrigation system

Total Suspended Solids (TSS)

During the study period, the TSS value varied from 37 to 79 ppm (mean value 50.15 ± 9.72 ppm) and statistically significant (p=0.00) during cultivation period and from 38 to 64 ppm (mean value 43.63 ± 8.38 ppm) and show significant different (p=0.00) during harvesting period. The lowest TSS value was obtained near to the dam while the maximum value was obtained at the tail end of RB canal (Figure 3). The level of TSS showed high fluctuation during cultivation period. However, there was no such fluctuation up to 17 km at harvesting time. The TSS level of RB canal water falls within the acceptable range of 50-100 ppm for irrigation (FAO, 1985).

Total Dissolved Solids (TDS)

The TDS showed high variation along the canal ranged from 10 to 250 ppm (mean value 55.21 ± 72.43 ppm) and statistically shows significant (p=0.00)during cultivation period and it was from 10 to 220 ppm (mean value of 48.33 ± 59.83) show significant different along the canal with distance (p=0.001) at harvesting time (Figure 3). During both sampling periods, TDS levels was almost same up to 16 km and then showed substantial increase and reached the maximum value at the tail end. It might be due to the mixing of eroded particulate matter and sediments from the agricultural fields with canal water. The results are on par with the results obtained by Mustapha *et al*. (2008) in a similar study. According to the FAO (1985), acceptable TDS for irrigation water is lesser than 2000 ppm. Hence, TDS level of RB canal water is below the acceptable limit.

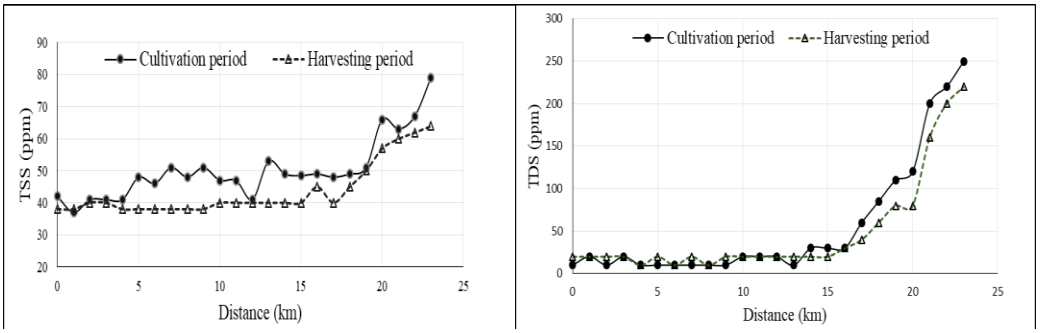

Figure 3: Variation of water quality parameters such as TSS and TDS during cultivation and harvesting periods in RB canal of Unnichchai irrigation system

Sodium (Na^+)

The Na^+ value varied from 0.53 to 14.6 ppm (mean value 5.74 ± 4.96 ppm) and during the cultivation period. The range was 0.59 - 13.8 ppm (mean value 5.68 ± 4.62 ppm) at harvesting time (Figure 4). By using chi- square test Na^+ shows significant difference in both sampling periods ($p<0.05$) As observed the graph, there was significant increase in Na^+ level after 15 km from the tank during both periods. Geological conditions and wastewater contamination may influence sodium concentration. As mentioned above, drainage water from the paddy fields in the downstream might have attributed for higher level of Na^+ in the downstream. According to FAO (1985), the acceptable level of Na^+ for irrigation water is <70 ppm. Therefore, RB canal water during both cultivation and harvesting periods fall within the acceptable level.

Potassium (K^+)

The potassium value varied from 4.3 to 6.4 ppm (mean value 5.4 ± 0.64ppm) during the cultivation period and this ranged was 1.5 - 7.9 ppm (mean value 3.08 ± 1.67 ppm) at harvesting time (Figure 4). Both sampling period K^+ value was statistically significant ($p<0.05$). Fluctuation in K^+ level was observed even after 15 km at harvesting time. It might be due to geological condition and discharge variation. In some locations, surface runoff with plant and animal residues mixed into the canal water in the downstream. It might have contributed for higher K^+ at the tail end. However, the K^+level of canal water was less than the maximum acceptable range of 5-10 ppm for irrigation (FAO, 1985).

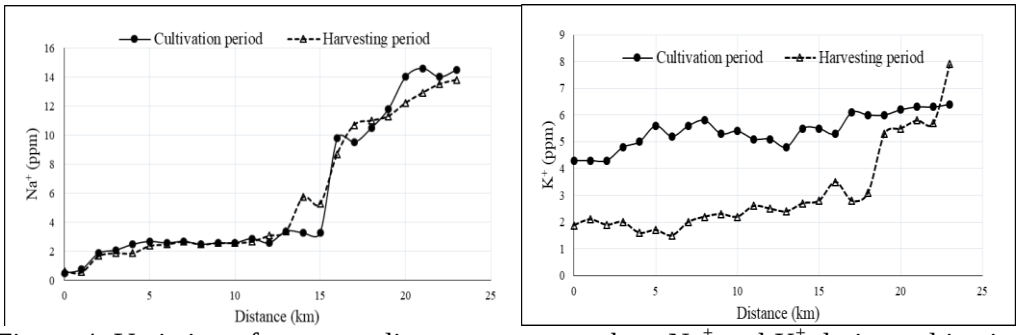

Figure 4: Variation of water quality parameters such as Na^+ and K^+ during cultivation and harvesting periods in RB canal of Unnichchai irrigation system

Calcium (Ca^{2+})

The Ca^{2+} content of the canal water varied from 1.2 to 3.4 ppm (mean value 2.09 ± 0.76 ppm) and (p=0.00) during the cultivation period and from 2.4 ppm - 3.8 ppm (mean value 3.05 ± 0.45ppm) and (p=0.00) during harvesting period (Figure 5). Statistically the Ca^{2+} is positively correlated with the distance (P<0.05) at both sampling periods. There was high temporal variation in Ca^{2+} concentration. Relatively high Ca^{2+} level observed at all location during harvesting. Fertilizers containing calcium component may enter into the canal and increase the calcium level (Raiswell, 1980). According to FAO (1985), the acceptable Ca^{2+} range for irrigation water is <100 ppm. However, Ca^{2+} concentration in the collected water samples was far below the maximum limit.

Magnesium (Mg^{2+})

The magnesium concentration varied from 1.19 to 2.42 ppm (mean value 1.72 ± 0.44 ppm) during cultivation period and from 1.44 to 2.88 ppm (mean value 2.04 ± 0.39 ppm) during harvesting (Figure 5). Using chi – square test the Mg concentration show the significant difference (P<0.05) with canal distance. The minimum Mg^{2+} level was obtained at the dam whereas the highest value was recorded at tail end. The Mg^{2+} value was high up to 16 km from dam. Thereafter, variation was relatively low. Concentration of Mg^{2+} showed more or less same values after 17 km. Drainage water from the paddy fields might be the reason for higher level of Mg^{2+} after 16 km distance from the dam. However, Mg^{2+} concentration of all water samples was less than the maximum acceptable level of 30 ppm for irrigation purpose.

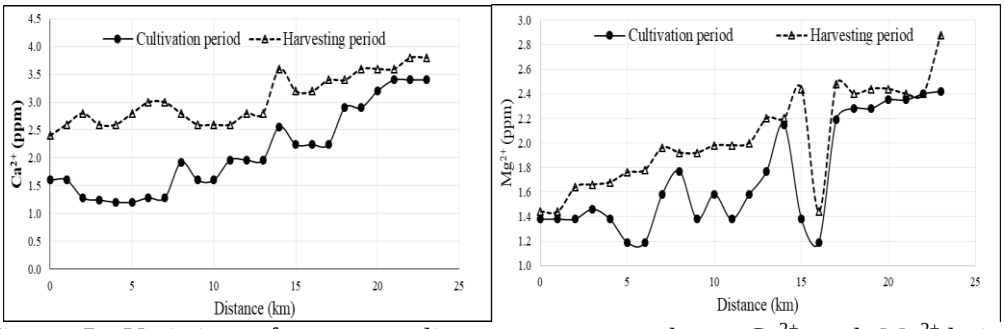

Figure 5: Variation of water quality parameters such as Ca^{2+} and Mg^{2+}during cultivation and harvesting periods in RB canal of Unnichchai irrigation system

Bicarbonate (HCO_3^-)

The bicarbonate level varies from 15 to 52 ppm (mean 27.17 ± 9.76 ppm) during cultivation period. During harvesting, it varied from 15 to 67 ppm (mean 27.21 ± 15.98 ppm) (Figure 6). There HCO_3^- statistically shows significant difference along the canal at both period of sampling (p=0.00). At the beginning of RB canal, concentration of bicarbonate was very low. However, the level reached to maximum at the tail end. Bicarbonate levels in water depend on weathering process in the catchment, rate of photosynthesis, respiration and organic decomposition in water (Mustapha, 2008). FAO (1985) indicated that acceptable bicarbonate range for irrigation water is <120 ppm. Accordingly, water from the RB canal is suitable for irrigation.

Phosphate

Figure 6 illustrates that the phosphate value ranged from 0.021 to 0.082 ppm (mean value 0.405 ± 0.022 ppm) during cultivation period and 0.018 –to 0.069 ppm (mean value 0.034 ± 0.017 ppm) during harvesting period. In statistically, phosphate was positively correlated with the canal distance. ($p<0.05$)The level of phosphate increased substantially after 15 km from the tank and reached the highest level at the tail end. Leached and runoff water enter into the canal may be a possible reason for elevated P levels. (Hodges *et al*., 2013). A number of discharge points can be found along the canal after 15 km distance. Discharge of agriculture runoff containing high level of fertilizers residues may cause nutrient enrichment in the canal water. In addition, sediment particles contain P molecules also enter into canal. According to FAO (1985), canal water fall within the acceptable limit of 2 ppm for the purpose of irrigation.

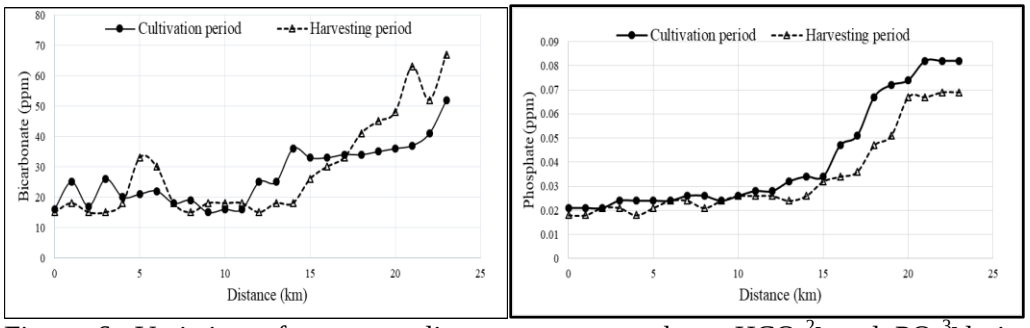

Figure 6: Variation of water quality parameters such as HCO_3^{2-} and PO_4^{3-}during cultivation and harvesting periods in RB canal of Unnichchai irrigation system

Derived quality parameters

Ca^{2+}/ Mg^{2+} ratio

The Ca^{2+}/Mg^{2+} ratio was higher at the head of the canal. Thereafter, this variation was reduced and showed high fluctuation with distance. The highest level was recorded at 16 km distance from the tank during both sampling periods (Figure 7). FAO (1985) indicated that the acceptable Ca^{2+}/Mg^{2+} ratio for irrigation water should be more than one. If it is less than one, there will be an Mg hazard to the plant. Bohn *et al*., (1985) reported that, if Mg content exceeds the Ca content, they prove equally toxic for soil properties and crop growth as the Na resulting in soil dispersion and decreased infiltration rate. The present study results shows that the Ca^{2+}/Mg^{2+} ratio of the RB canal was more than one therefore, the crop irrigated with this canal water will not be affected by Mg hazard.

Residual Sodium Carbonate (RSC)

The residual sodium carbonate (RSC) is another indicator used to evaluate the quality of irrigation water. **(**Richards 1954). Kumar *et al*., (2009) reported that the increase of RSC in irrigation water is significantly harmful to plant growth. Table 2 shows classification of water for irrigation based on RSC values.

Table 2: Classification of irrigation water based on RSC (Richards, 1954)

RSC value (mel/1)	Water quality
<1.25	Water can be used safely
1.25-2.5	Water can be used with certain Management
>2.5	Unsuitable for irrigation purpose

The RSC value of RB canal water ranged from 0.048 me/1 to 0.48 me/1 **(**mean value0.196± 0.107 mel/1)during the cultivation period and the range was 0.005 me/1 - 0.677 me/1 (mean value 0.1757± 0.206mel/1)during harvesting period (Figure 7). According to Table 2, water in the RB canal can be used safely as the SAR values of all collected samples were less than 1.25.

Sodium Adsorption Ratio (SAR)

Sodium Adsorption Ratio helps to evaluate the excess sodium concentration with calcium and magnesium concentration (Richards, 1954). Continuous application of water with high SAR leads to the increase Na level over the time, which in turn adversely reduces soil infiltration and percolation rates in the irrigated area. In addition, excessive SAR levels leads to soil crusting, poor seedling and poor aeration in agricultural land (Lesch and Suarez, 2009). The SAR values ranged from 0.07 to 1.48 (mean value 0.658 ± 0.492) during cultivation period and from 0.07 to 1.33 (mean value 0.587 ± 0.445) at harvesting time (Figure 7). A substantial increase in SAR values during both durations was observed after 15 km distance from the tank. Table 3 shows suitability class of irrigation water based on SAR values. The present study revealed that the level of SAR of RB canal water was below 10 and thus sodium hazard is very low in this water.

Table 3: Classification of irrigation water based on SAR values (Richards, 1954)

Water class	SAR value	Remarks
Low sodium hazard	0-10	Little or no hazard
Medium-sodium hazard	10-18	Appreciable hazard but can use with
High sodium hazard	18-26	Unsatisfactory for most crops
Very high sodium hazard	>26	Unsatisfactory for most crops

Soluble Sodium Percentage (SSP)

The SSP value ranged from 9.9 to 46.1% (mean value 33.1 ± 9.6%) during the cultivation period whereas it was from 8.8 to 44.1% (mean value 28.4 ± 10.3%) during harvesting period (Figure 7). The value was slightly higher during cultivation period than harvesting time. Table 4 shows the suitability classification of irrigation water based on SSP values. The SSP values of water up to 16 km from the tank were below 40%. It falls under class 1 and thus it is good for irrigation. However, from 17 km the SSP values of canal water samples fall under class 2 and thus canal water after 17 km is slightly injurious to the receiving soil.

Table 4: Classification of irrigation water based on SSP values (Eaton, 1950**)**

Class	SSP%	Suitability of water for irrigation
1	< 40	Good
2	40-70	Slightly injurious
3	> 70	Unsatisfactory

Water intended for agricultural use should have a lower concentration of sodium ions and higher concentrations of calcium and magnesium ions. Excessive amounts of Na ions may cause a significant decrease in the permeability of agricultural soils.

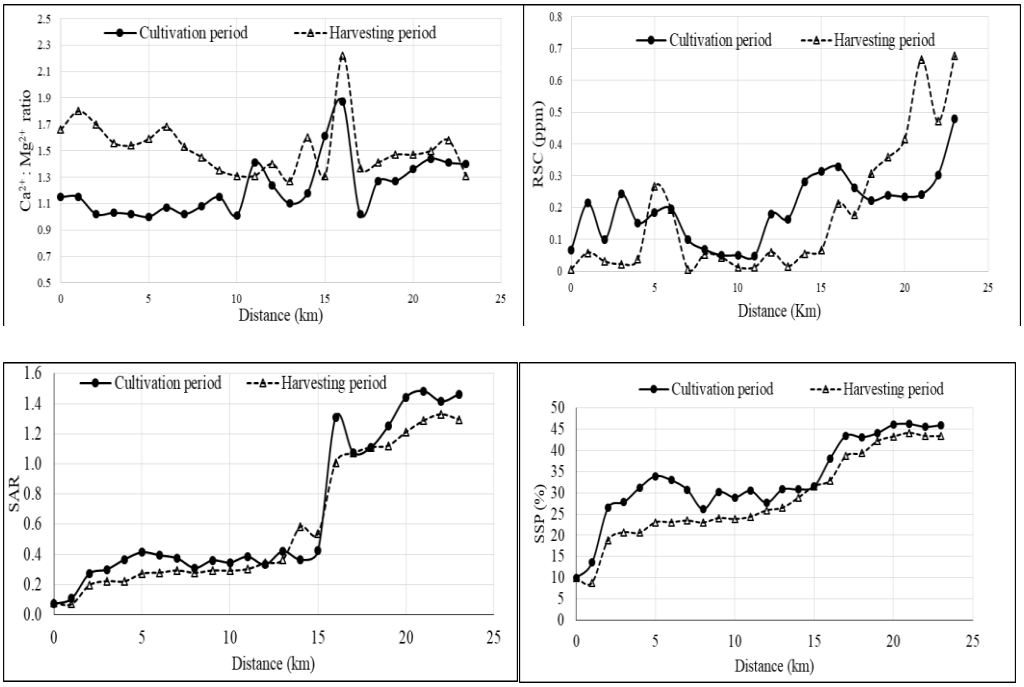

Figure 7: Variation of derived quality parameters along the RB canal of Unnichchai irrigation system during two sampling periods

Conclusions

Quality of RB canal water shows spatial and temporal variations. Statistically parameters show positive correlation with the canal distance. The level of TSS, TDS and PO_4^{3-} found to be below the maximum limit for irrigation purpose. However, EC level exceeded the limit at the tail end during cultivation period. The derived parameters such as Ca^{2+}/Mg^{2+} ratio, RSC and SAR revealed that the quality of RB canal water is adequate for irrigation use. However, the level of SSP exceeded the acceptable limit of 40% at the tail end of the canal. Further, level of selected quality parameters are more or less constant up to 15 km distance from the tank and thereafter it increased substantially. In overall, water in the RB canal of Unnichchai irrigation system is suitable for irrigation purpose. However, appropriate management intervention is needed to reduce water pollution, especially after 15 km distance of RB canal.

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VARIATION OF IRRIGATION WATER QUALITY WITH PUMPING DURATION AT TWO COASTAL VILLAGES OF BATTICALOA DISTRICT

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Abstract

Groundwater quality deterioration in the coastal areas due to excess pumping is concerned recently due to shortage of surface water. The present study was aimed to investigate the variation of groundwater quality with pumping duration in Kaluthavalai and Cheddipalayam farming villages in the coastal area of Batticaloa district. Groundwater samples were collected in July, 2018 from six agricultural fields from each village at different pumping durations (01, 21, 41 and 61-minutes) and analysed for some important water quality parameters such as pH, EC, TDS, TSS, Ca^{2+}/Mg^{2+} ratio and Sodium Adsorption Ratio (SAR). The study revealed that there were some variations observed in water quality parameters with pumping duration. However, the variation was not significant ($\leq$0.05).The pH, EC, TDS and TSS ranged from 6.94 - 7.04, 0.5 - 1.53 dS/m, 250 - 760 mg/l and 32 - 546 mg/l, respectively. The Ca^{2+}/Mg^{2+} ratio and SAR varied from 0.43 - 6.0 and 0 - 3.94 respectively. High level of EC and TDS was observed in Kaluthavalai area. However, Cheddipalayam area recorded high level of SAR. Further, significant variation ($\leq$0.05) was observed in EC, TDS and SAR between the readings taken at Kaluthavalai and Cheddipalayam areas at all pumping durations. In overall, one-hour pumping duration did not have significant impact on groundwater quality in both areas. Even though some quality parameters were at high level, groundwater in these farming areas is suitable for irrigation purposes.

Keywords: Coastal aquifers, Groundwater, Irrigation water quality, Salinity

Introduction

Groundwater is one of the most important natural resources, widely used for domestic, irrigation, commercial and industrial, water supply schemes and other purposes. The availability of groundwater offers farmers to grow more crops, minimize the damage caused by droughts, and achieve enhanced incomes from higher cropping intensity and cultivation of high-value crops (Pathmarajah, 2016). Aquifers in the coastal areas are recharged during rainy seasons or from nearby surface water sources. Volume of the fresh water in these aquifers increases during the rainy seasons and contracts during the dry seasons (Sugirtharan and Rajendran, 2015). Groundwater quality deterioration in the coastal areas due to excess pumping is concerned recently due to shortage of surface water. Groundwater quality in an aquifer differs with depth due to aquifer geology and rock formation having different chemical characteristics (Michael, 1992).

Further, depletion of groundwater level by continuous pumping from an aquifer may degrade water quality (Al-Naeem, 2014). It is well known that over pumping of fresh water aquifers leads to seawater intrusion in the coastal areas. In general, salinity problem in coastal aquifers is observed when the depletion of freshwater aquifers is faster than the recharge.

Kaluthavalai and Cheddipalayam are the two popular intensive farming villages in the coastal area of Batticaloa district in Sri Lanka. Groundwater is the only source of water for irrigation. Farmers have adopted sprinkler irrigation technology to irrigate the crops. They irrigate the crops more frequently due to low water holding capacity of the soil in these areas. Over exploitation of groundwater from this shallow coastal aquifer may cause saline water intrusion. So far, the variation of water quality with the pumping durations in these areas is not well documented. Assessment of irrigation water quality with pumping duration would be useful to manage the freshwater aquifer for sustainable crop production in these areas. In the above context, the present study was carried out to assess the variation of irrigation water quality with pumping duration in these two farming villages.

Materials and Methods

Study area

The present study was carried out at Cheddipalayam and Kaluthavalai villages in Batticaloa district. The latitude and longitude of Cheddipalayam and Kaluthavalai are $7^{o}34'$N & $81^{o}47'$E and $7^{o}32'$N & $81^{o}47'$E, respectively. Both areas fall under DL2b agro-ecological region, which receives an average annual rainfall about 1,700 mm. Most of the farmers cultivate chilli as the main crop. Groundwater in the sandy aquifer is the only source of water used for irrigation, domestic and drinking purposes.

Site selection and sampling

Irrigation water samples from twelve farms, six from each village, at one minute, twenty-one minutes, forty-one minutes and sixty-one minutes of pumping duration were collected in July, 2018. The depths of the tube wells were between 15 to 20 feet. The pumping rate of the pumps was 564.5 l/min. The bottles were rinsed two to three times with sample water before taking water samples. The procedure was repeated thrice to get average values. Figure 1 shows the location of study area and sampling locations at each village.

Analysis of samples

In-situ measurements were taken for parameters such as pH, electrical conductivity (EC) and total dissolved solids (TDS) using portable digital pH/EC/TDS meter (model: HI 98130) respectively. Calcium was analysed by titration with Versenate (Ethylenediaminetetraacetatic acid) using calcon as an indicator.Calcium and magnesium were analysed by titration with Versenate (EDTA) using Erichrome Black T as an indicator. Magnesium concentration was calculated by deducting the calcium concentration from total concentration of calcium and magnesium. Sodium and potassium were analysed by flame photometer using standard solutions of sodium

nitrate and potassium nitrate. Carbonate and bicarbonate were analysed by titration with standard sulphuric acid using methyl orange and phenolphthalein as indicators.

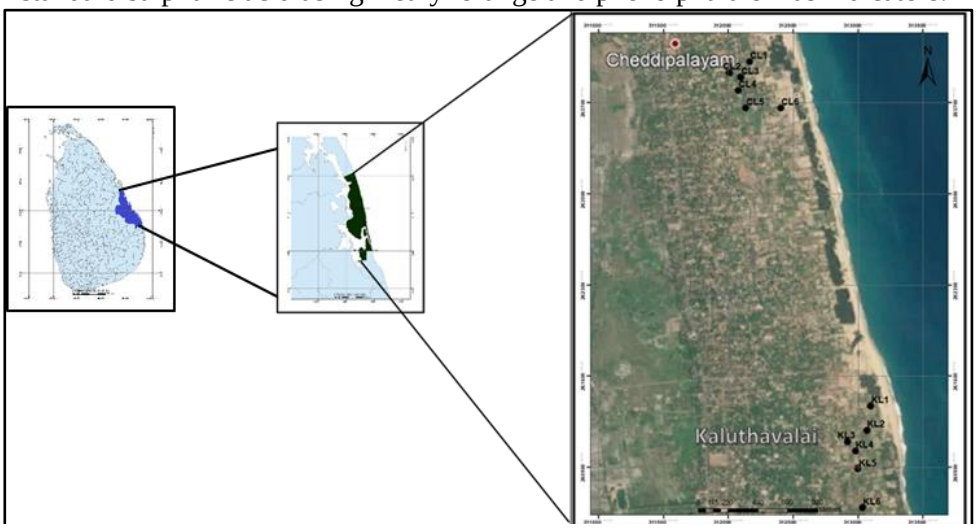

Figure 1: Sampling locations at Cheddipalayam (denoted by CL) and Kaluthavalai (denoted by KL) areas

Total suspended solids (TSS) were measured by oven dry method. The derived parameters such as sodium absorption ratio (SAR) and calcium magnesium ratio were determined using the following formulae for the easy understanding of the quality of irrigation water at different pumping durations.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Calcium Magnesium ratio = Ca^{2+}/Mg^{2+}

Where, all the cations are expressed in meq/l.

Results and Discussion

pH

According to this study, pH of the water varied from 6.95-7.04 at Kaluthavalai and from 6.94-7.03 at Cheddipalayam (Figure 2). It indicates that the groundwater is neutral in nature in both areas. The level of carbonates and bicarbonates influences pH level of water (Murhekar, 2011). Presence of carbonate rocks in the geology of the aquifer may influence the variation of pH level. There were some fluctuations in pH with pumping duration. However, the pH levels at all pumping duration were within the acceptable range of 6.5 to 8.4 for irrigation water (Ayers and Westcot, 1985) in all pumping durations.

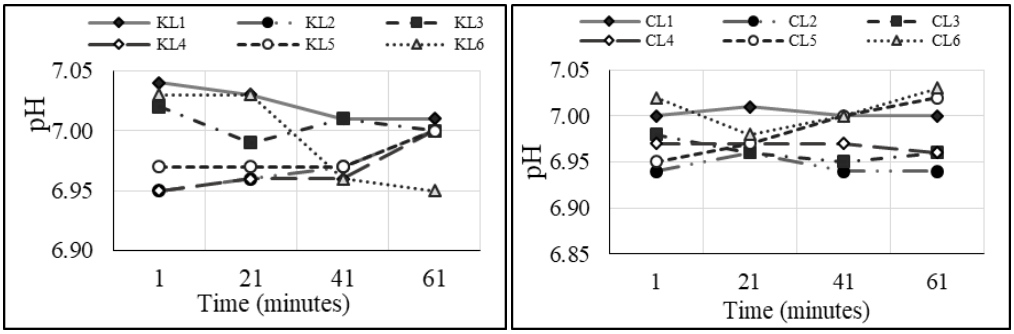

Figure 2: Variation of pH with pumping duration at Kaluthavalai and Cheddipalayam areas

***Electrical Conductivity* (EC)**

The EC can be a measure of the total dissolved solids of water and it is considered as index of salinity hazards. It was observed that the EC of the groundwater varied from 1.02-1.53 dS/m at Kaluthavalai and from 0.5 - 1.21 dS/m at Cheddipalayam (Figure 3).

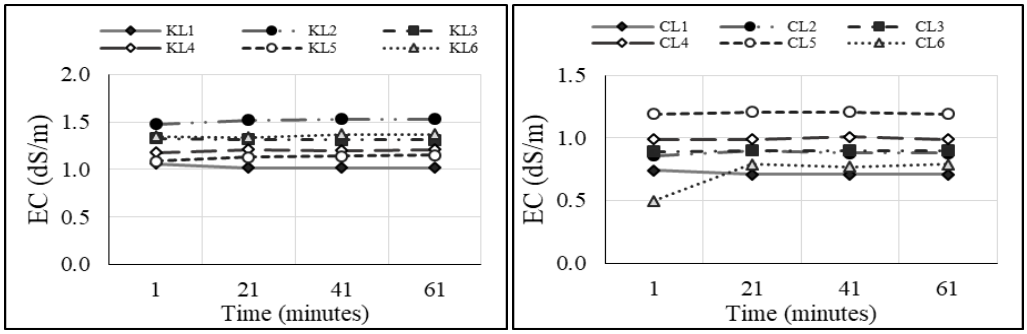

Figure 3: Variation of EC with pumping duration at Kaluthavalai and Cheddipalayam areas

This variation may be due to the location of the wells. The variation of EC was not statistically significant with pumping duration for each location. However, there were some fluctuations observed at CL6. This may be due to seawater intrusion at CL6. According to Table 1, groundwater in these areas exceeded the desirable limit of 0.5 dS/m (Richards, 1954) falls under high salinity class in all pumping durations except at one-minute at CL6.

Table 1: Classification of irrigation water based on EC values (Richards, 1954)

Water class	EC (dS/m)	Remarks
Low salinity	< 0.16	Can be used safely
Medium salinity	0.16 – 0.5	Can be used with moderate leaching
High salinity	0.5 - 1.5	Cannot be used for irrigation purposes
very high salinity	1.5 – 30	

***Total Dissolved Solids* (TDS)**

The TDS is the measures of salt content in water as salts constitute important part of TDS. Irrigation water with TDS less than 450mg/l is considered good, and that with greater than 2000 mg/l is unsuitable for irrigation purpose (Ayers and Westcot, 1985). The TDS level of groundwater varied from 510 - 760 mg/l at Kaluthavalai and from 250 - 600 mg/l at Cheddipalayam (Figure 4). The level of TDS was above 450 mg/l at Kaluthavalai in all pumping durations. However, TDS levels were within minimum range at Cheddipalayam in all pumping durations except at CL4 and CL5.

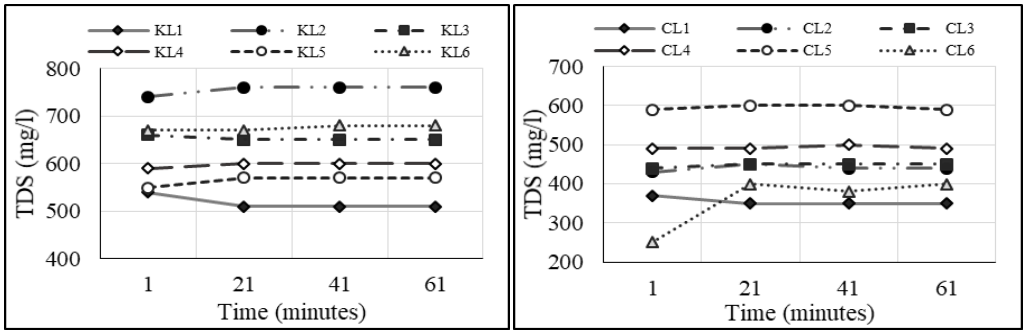

Figure 4: Variation of TDS with pumping duration at Kaluthavalai and Cheddipalayam areas

***Total Suspended Solids* (TSS)**

The level of TSS ranged from 130 -464 mg/l at Kaluthavalai and from 32 -546 mg/l at Cheddipalayam (Figure 5). According to Ayers and Westcot (1985), the acceptable range of TSS for irrigation water is 50-100 mg/l. Accordingly, groundwater in these areas except CL6 (at 1-minute and 21- minutes) exceeds the acceptable range in all pumping durations.

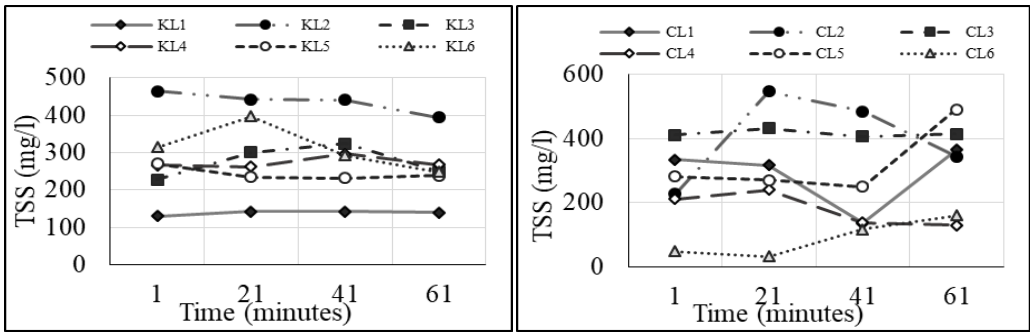

Figure 5: Variation of TSS with pumping duration at Kaluthavalai and Cheddipalayam areas

Ca^{2+}/Mg^{2+}*ratio*

Ayers and Westcot (1985) indicated that the Ca^{2+}/Mg^{2+} ratio of irrigation water should be more than one. If the ratio is less than one, it becomes toxic for soil properties and crop growth as the Na causes the soil dispersion and infiltration rate reduction (Bohn *et al.*, 1985). In the present study, it was found that the ratio ranged from 0.6- 6.0 at

Kaluthavalai and from 0.43 – 6.0 at Cheddipalayam (Figure 6). Except KL3 and CL1, the ratio was higher than 'one' in all pumping durations.

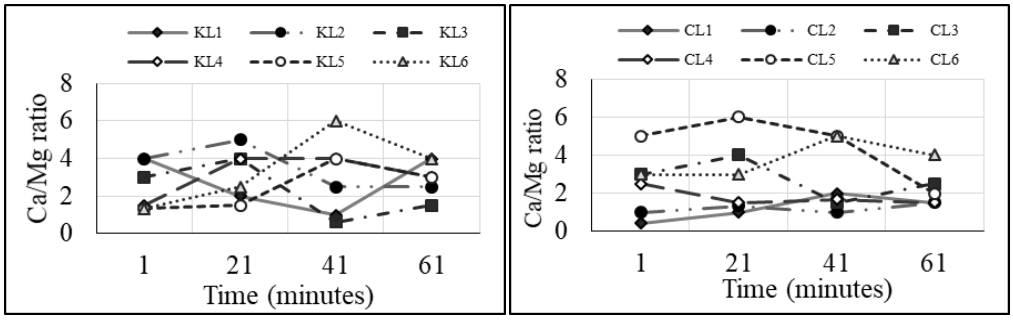

Figure 6: Variation of Ca/Mg ratio with pumping duration at Kaluthavalai and Cheddipalayam

***Sodium Adsorption Ratio* (SAR)**

Sodium Adsorption Ratio (SAR) is the index of sodium hazards. It is calculated from the concentration (meq/l) of sodium, calcium and magnesium ions (Karanth, 1987).The SAR of water samples ranged from 0 to 1.6 at Kaluthavalai and the values varied from 1.75 to 3.94 at Cheddipalyam (Figure 7). Although there was high spatial variation in SAR values at 1 minute of pumping, this variation was reduced with pumping duration. Further, the SAR values of irrigation water at Cheddipalayam were relatively higher than Kaluthavalai. However, SAR values at both areas were below 10 at all pumping durations. Therefore, water used for irrigation in both areas comes under low sodium hazard class (Richards, 1954).

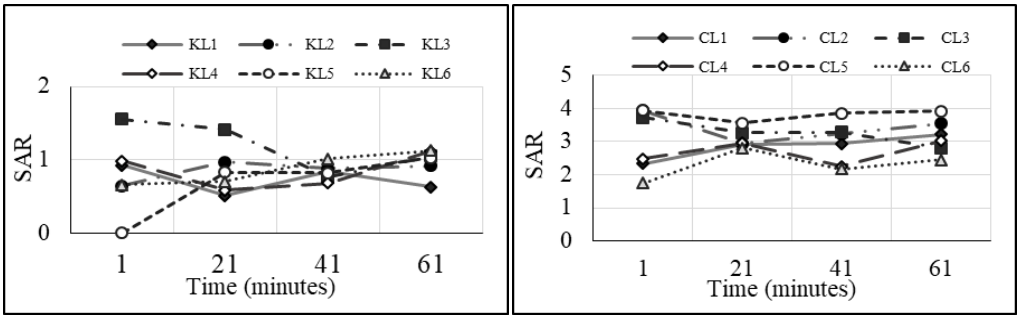

Figure 7: Variation of SAR with pumping duration at Kaluthavalai and Cheddipalayam areas

Mean comparison of water quality parameters

The comparison was done between two study areas for each pumping duration. There was no significant variation of water quality parameters with pumping duration in both villages, as far as the locations are concerned; there was no significant difference in pH and TSS level between two locations. However, significant difference ($p \leq 0.05$) was observed in EC and TDs between Kaluthavalai and Cheddipalayam areas at all pumping durations (Table 2). The higher mean value of EC and TDS was observed at Kaluthavalai.

Table 2: Mean comparison of water quality parameters between two study areas

Parameters	Duration (min)	Kaluthavalai	Cheddipalayam	Significance
pH	1	6.99 ± 0.02	6.98 ± 0.01	P>0.05
	21	6.99 ± 0.01	6.98 ± 0.01	P>0.05
	41	6.98 ± 0.01	6.98 ± 0.01	P>0.05
	61	6.99 ± 0.01	6.98 ± 0.02	P>0.05
EC(dS/m)	1	1.25 ± 0.07	0.86 ± 0.09	P<0.05
	21	1.26 ± 0.07	0.92 ± 0.07	P<0.05
	41	1.26 ± 0.07	0.91 ± 0.07	P<0.05
	61	1.27 ± 0.07	0.91 ± 0.07	P<0.05
TDS(ppm)	1	625.0 ± 31	428.3 ± 46.6	P<0.05
	21	626.7 ± 35	456.7 ± 34.8	P<0.05
	41	628.3 ± 35	453.3 ± 36.5	P<0.05
	61	628.3 ± 35	453.3 ± 33.5	P<0.05
TSS(ppm)	1	278.7± 44	252.3 ± 50.5	P>0.05
	21	296.0± 44	306.0 ± 71.7	P>0.05
	41	287.7± 99	255.3 ± 63.7	P>0.05
	61	256.3± 33	317.0 ± 58.3	P>0.05

Similarly, derived parameter SAR was also showed significant difference ($p \leq 0.05$) between Kaluthavalai and Cheddipalayam areas at all pumping durations (Table 3).However, significant difference was not observed for Ca^{2+}/Mg^{2+} ratio. Further, higher mean values of derived parameters except Ca^{2+}/Mg^{2+} ratio was observed at Cheddipalayam.

Table 3: Mean comparison of derived water quality parameters

Parameters	Duration	Kaluthavalai	Cheddipalayam	Significance
SAR	1	0.79 ± 0.21	3.03 ± 0.39	P<0.05
	21	0.83 ± 0.13	3.08 ± 0.12	P<0.05
	41	0.83 ± 0.05	2.96 ± 0.26	P<0.05
	61	0.98 ± 0.08	3.16 ± 0.21	P<0.05
Ca^{2+}/Mg^{2+} ratio	1	2.53 ± 0.53	2.49 ± 0.67	P>0.05
	21	3.17 ± 0.56	2.81 ± 0.79	P>0.05
	41	3.02 ± 0.84	2.70 ± 0.74	P>0.05
	61	3.00 ± 0.39	2.17 ± 0.40	P>0.05

Conclusions

The study revealed that the variation in quality of groundwater is not significant. Some quality parameters such as EC, TDS and SAR show significant variation between two areas for all pumping durations. Comparatively, Kaluthavalai area has high level of EC and TDS whilst Cheddipalayam has high level of SAR. In overall, level of water quality parameters is within the acceptable limit for irrigation in both areas. One-hour pumping duration does not have significant impact on quality of water. However, level of some quality parameters shows an increasing trend with pumping duration in some areas. Therefore, it is recommended to assess the groundwater quality with extended

pumping duration as famers in these areas irrigate the crops for 3 to 4 hours continuously.

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INFLUENCE OF SOIL MOISTURE LEVELS AND FERTILIZER POTASSIUM ON POTASSIUM CONTENT AND YIELD OF COWPEA (*Vigna unguiculata*) IN SANDY REGOSOL

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Abstract

Cowpea (*Vigna unguiculata*) is an important legume crop widely cultivated in Sri Lanka, has great potential for improving human nutrition due to its high protein content. However, drought stress was found to be one of the major constraints to cowpea production in Sri Lanka. Potassium decreases drought stress effects in plants. A study was conducted from July to September 2018 to investigate the effect of four rates of fertilizer potassium (MOP) including recommended level (75Kg/ha), 125% of recommended level, 150% of recommended level, 175% of recommended level with two different soil moisture levels as optimal (25% depletion of available soil moisture) and sub-optimal (75% depletion of available soil moisture) on potassium content and yield of cowpea. These 8 treatments replicated three times in a Completely Randomized Design (CRD) in a factorial manner. Potassium content and yield parameters of cowpea were recorded. The data were statistically analyzed using SAS and difference between treatment means was compared using Duncan's Multiple Range Test (DMRT). Water stress produced significant effects (P<0.05) on potassium content and yield parameters. The number of pods per plant showed a greater response to potassium fertilizer under optimal soil moisture. Although differences were observed in the responses of potassium content and yield of cowpea to moisture and potassium, in overall terms potassium promoted potassium content and yield of cowpea when subject to optimal and suboptimal soil moisture. Among all applications 175% of recommended potassium level of cowpea proved to be the best to increase the potassium content and yield under optimal and sub-optimal moisture conditions compared to recommended level of potassium in sandy regosol. The results of this study suggested that the increased application of potassium fertilizer can be considered as significant factor in overcoming soil moisture stress in cowpea.

Keywords: Cowpea, Drought, Moisture, Potassium, Yield

Introduction

World population is growing at a higher rate and its greatest impacts are on the developing countries of Asia and Africa. Sri Lanka is a South Asian developing country mainly depends on agriculture for the economic growth and affected by increasing population (Sangakkara and Nissanka, 2017). Due to this, food security has become a major issue in Sri Lanka. Hence to enhance the crop productivity to ensure food security is more important to provide better nutrition to our people.

Water is becoming a scarce commodity for irrigation especially under the present changing climatic scenario. Scarcity of water for agriculture has a negative impact on the crop production. Drought is the most severe abiotic stress which affects the growth and yield of various crops (Sara and Roghieh, 2017). It is important to recover from abiotic stress to increase the food production to feed the increasing population.

Cowpea is an important legume crop widely cultivated in Sri Lanka. It is an inexpensive and rich source of protein.Cowpea is often subjected to drought stress in both seedling and terminal growth stages which cause a considerable amount of loss in yield. Among the plant nutrients, potassium (K) is one of the major nutrients essential for the plant growth and physiology. Under drought stress condition potassium regulates the stomatal opening and makes the plants adaptive to water deficit (Mirza *et al*., 2018). So, drought stress cultivars combined with adequate external potassium supply may be a good strategy to increase the productivity in arid and semi-arid regions. Some findings showed that yield limiting effect of water stress could be overcome by increasing potassium supply (Sara and Roghieh, 2017).

The predominant soil group in Batticaloa district and the coastal belt of Eastern province, Sri Lanka is sandy regosol (Quartzipsamments) which contain 95-98% sand with no confining horizons in its soil profile (Bawatharani *et al*., 2004). Sandy regosol soil is light and easy to work. Also the cultivation can be carried out all year round and it favours better air and water movement and root penetration.

Though the effects of water stress on cowpea production have been studied, a little is known about the effects of water stress on yield components. A better understanding of the effects of water stress on cowpea yield will provide useful information to farmers on how to manage the cowpea production under drought conditions, and also a few studies have demonstrated that the use of potassium fertilizer can reduce the adverse effects of water stress in cowpeas in controlled environmental conditions (Fooladivanda *et al*., 2014). Fertilizer potassium would be expected to have some effects on cowpea in overcoming moisture stress. Though there are ample amount of research findings on the impact of potassium on the yield of cowpea under moisture stress there is no such amount of data for the crop grown under exposed environmental conditions. Therefore to, investigate this possibility, an experiment was carried out under exposed environmental conditions in the sandy regosols of Batticaloa district to determine the impact of fertilizer potassium on the potassium content and yield of cowpea under the two different soil moisture levels.

Materials and Methods

Description of experimental site

The experiment was conducted during the Yala season of the year 2018 at the Eastern University, Sri Lanka which is situated in the Batticaloa district, Sri Lanka. The elevation of this area is 75m above mean sea level and it is classified under the agro-ecological zone of the low country dry zone (DL_2). The mean annual rainfall of

Batticaloa district varies from 1800mm to 2100 mm and most of the showers were received during the months of October to January (Maha season) brought about by the North East monsoon. The annual mean temperature varies from 28 to 32^0c and humidity ranges from 60% to 90%.

Description of the experiment and growth conditions

A pot experiment was carried out from July to September, 2018 in a wire house with rainproof roof, in order to avoid interruption by rainfall. The soil was collected from the surface layer (0-15 cm) of the Crop Farm, Eastern University, Sri Lanka. The soil used in this study was sandy regosol. Cowpea seeds of Wijaya variety were used for this experiment and seeds were collected from the seed unit of Crop Farm, Eastern University, Sri Lanka.

Black polythene bags were used for this experiment with the dimension of 36cm in diameter and 40cm in height. A bulk soil sample was collected was processed, air dried and sieved by using 2mm mesh sieve, for homogeneity. Each polythene bag was filled with seven (7) Kg of processed soil. Then they were properly labeled and arranged according to the design. Nitrogen and phosphorus fertilizers were incorporated with the soil as per the recommendation and potassium was incorporated according to the treatments. Four seeds were sown in each bag and two weeks after germination, two plants per bag were maintained and all the agronomic practices were applied according to the recommendation of Department of Agriculture, Sri Lanka.

Experimental design and preparation of treatments

The experiment was conducted in two factor factorial completely randomized design with eight treatments (4 potassium levels and 2 soil moisture conditions) and three replicates. A total number of 24 bags were used for this experiment.

Treatments

Soil's field capacity (52%) was measured in volume basis (Wang *et al*., 2012). Depletion of available soil moisture at 25% and 75% were determined in volume basis and defined as optimal moisture level and sub-optimal moisture level, respectively. Soil moisture was monitored at every two days interval by weighing the bags (Lopo de Sá *et al*., 2014).

Treatment structure

F1K1- Sub-optimal moisture level+potassium at 125% of recommendation
F1K2- Sub-optimal moisture level+potassium at 150% of recommendation
F1K3- Sub-optimal moisture level+potassium at 175% of recommendation
F1K0- Sub-optimal moisture level+potassium at recommendation (control)
F2K1- Optimal moisture level+potassium at 125% of recommendation
F2K2- Optimal moisture level+potassium at 150% of recommendation
F2K3- Optimal moisture level+potassium at 175% of recommendation
F2K0- Optimal moisture level+potassium at recommendation (control)

According to the Department of Agriculture recommendation the optimum potassium level for cowpea is 75kg/ha. For this experiment 25%, 50% and 75% increase of recommended potassium levels were used and they were defined as 125%, 150% and 175% potassium level, respectively. According to the recommended above rates, treatments were applied to the bag three days before planting.

Measurements

Potassium content and yield parameters of cowpea were measured to evaluate the performances of cowpea in each treatment at harvesting stage (60 days after planting).

- Potassium content in plant at harvest (mg/g) - measured using flame photometer
- Pod number per plant
- Seed weight per pod(g) – measured using electronic balance
- Yield (Kg/ha)

Statistical analysis

All the data were analyzed using Analysis of Variance (ANOVA) procedure to know the variance if any at the treatment level. Duncan's Multiple Range Test (DMRT) was used to compare the significant differences between treatment means at $p < 0.05$ using SAS 9.1.3 statistical software package.

Results and Discussion

Potassium content in plant at harvest

The results pertaining to the available potassium content in plant at harvest indicated that there was a significant influence of soil moisture and fertilizer potassium on the available potassium content in plant at harvest as *P* value is less than 0.05 (Table 1). The results showed that the available potassium content was high under optimal moisture level compared to sub-optimal moisture level. Similar results were found by Felício Lopo de Sá *et al*. (2014) and he stated that potassium contents in plants were greater under conditions of high moisture. Reduction in potassium content under sub-optimal condition may due to low uptake of potassium under low soil moisture level. Because potassium mobility to the roots from soil is low under low soil moisture level. Wang *et al*. (2013) reported that soil moisture can influence the uptake rate of potassium via affecting its mobility from the soil to the root surface. 175% potassium level significantly increased the available potassium content in plant. This was supported by FelícioLopo *et al*. (2014). This may be due to the high potassium application to the soil. Wang *et al*. (2013) stated that higher application rate of potassium fertilizer was responsible for larger potassium concentrations in all organs. Mahouachi *et al*. (2006) found that highest potassium doses in the soil resulted in a greater accumulation of this element in plant tissues.

Asao *et al*. (2013) reported that changes in the potassium supply to a growing plant can cause significant alterations of the potassium content in the melon plant tissues. The interaction between the moisture level and potassium rates had a significant effect on

plant potassium content on harvest. Under optimal moisture level 175% potassium level significantly increased the plant potassium content.

Table 1: Effect of soil moisture level and potassium rates on available potassium content in plant (mg/g) at harvest in cowpea

Rate of MOP	Potassium Content in Plant(mg/g)	
	Sub-optimal moisture	Optimal moisture
125%	2.27± 0.02[b]	2.72± 0.14[b]
150%	2.31± 0.02[b]	2.77± 0.02[b]
175%	2.39± 0.01[a]	3.36± 0.12[a]
Recommendation	2.18± 0.01[c]	2.64± 0.01[b]
	Moisture content	$P < 0.05$
	MOP	$P < 0.05$
	Interaction	$P < 0.05$

Means with dissimilar letters within the spacing are significant (p < 0.05).

This may due to increased mobility of potassium under high moisture level Wang *et al*., (2013). Under sub-optimal moisture level also 175% potassium level significantly increased the plant potassium content. This may due to increased accumulation of soil potassium by the extended root growth due to moisture stress. Sangakkara *et al*. (2001) stated that under low moisture levels plants extend their roots to absorb moisture from the deeper layers of soil and they absorb more soil potassium.

Pod number per plant

The results belong to the pod number per plant indicated that there was a significant influence of soil moisture on number of pods per plant as *P* value is less than 0.05 (Table 2). The highest number of pods (4.0) was observed in plants subjected to optimal moisture and the lowest (1.0) was observed in the plants subjected to sub-optimal moisture. This result is in conformity to the results observed by Manjeru *et al*. (2007). Abelardo *et al*. (2005) stated that, the yield component mostly affected during the stress period was pods per plant.Reduction of number of pods with reduced moisture level may be due to the abscission of flowers caused by moisture stress. This was supported by Boutraa and Sanders (2001). Islam *et al*. (2004) concluded that under severe stress, pod number is decreased. Xia (1994) further stated that under water stress, the decrease on the number of flowers and pods for some legumes is due to a great extent to a limited vegetative growth. Limiting the vegetative growth of branches may decrease the source-sink relationship between leaves and pods (Abelardo *et al*., 2005).

The results pertaining to the pod number per plant indicated that there was a significant influence of potassium rates on number of pods per plant as *P* value is less than 0.05 (Table 2). Increasing level of potassium significantly increased the pods per plant under optimal moisture level. 175% potassium level also increased the pod number compared to recommended, 125% and 150% levels under sub-optimal condition. Islam *et al*. (2004) stated that potassium increased the number of pods per plant irrespective

of the levels of soil moisture. This might be due to the highest potassium content in plants with increasing potassium level (Table 1).

Table 2: Effect of soil moisture level and potassium rates on the number of pods / plant

Rate of MOP	Number of Pods per Plant	
	Sub-optimal moisture	Optimal moisture
125%	1.0 ± 0.3^{a}	3.0 ± 0.3^{ab}
150%	2.0 ± 0.7^{a}	3.0 ± 0.3^{ab}
175%	2.0 ± 0.3^{a}	4.0 ± 0.3^{a}
Recommendation	1.0 ± 0.7^{a}	3.0 ± 0.3^{b}
	Moisture content	$P < 0.05$
	MOP	$P < 0.05$
	Interaction	$P > 0.05$

Means with dissimilar letters within the spacing are significant (p < 0.05).

Seed weight per pod

The results relating to the seed weight per pod of cowpea plant indicated that there was a significant influence of soil moisture on the seed weight of cowpea as *P* value is less than 0.05 (Table 3). The results showed that the seed weight per pod of cowpea was greater under optimal moisture than sub-optimal. The highest reading observed was 2.97g under optimal and the lowest was 0.58g under sub-optimal. It clearly shows that seed weight per pod of cowpea plants reduced with reducing soil moisture. This may due to reduced assimilate supply to the seed under water stress condition (Vorasoot *et al*., 2003). The results pertaining to the seed weight per pod indicated that there was a significant influence of potassium rates on seed weight per pod as *P* value is less than 0.05 (Table 3).Increasing potassium rates significantly increased the seed weight per pod under both moisture levels. This may due to the impact of potassium on the seed weight of cowpea plants. This was clearly supported by Shafeek *et al.* (2005), who stated that increased application of fertilizer potassium produce high seed weight and consequently increase the total yield.

Table 3: Effect of soil moisture level and potassium rates on the seed weight per pod of cowpea plant (g)

Rate of MOP	Seed Weight per Pod(g)	
	Sub-optimal moisture	Optimal moisture
125%	0.64 ± 1.06^{c}	2.62 ± 0.0^{b}
150%	1.91 ± 2.14^{b}	2.6 ± 0.43^{c}
175%	2.09 ± 0.0^{a}	2.97 ± 0.43^{a}
Recommendation	0.58 ± 1.06^{d}	1.52 ± 0.43^{d}
	Moisture content	$P < 0.05$
	MOP	$P < 0.05$
	Interaction	$P < 0.05$

Means with dissimilar letters within the spacing are significant (p < 0.05).

The interaction between the moisture level and potassium rates had a significant effect on seed weight per pod as *P* value is less than 0.05 (Table 3) High soil moisture level

with 175% potassium rate significantly increased the seed weight per pod. This may due to increased assimilate translocation to the seeds by the activity of potassium under optimal soil moisture level. This was supported by Sangakkara (2000).

Yield

The results pertaining to the yield of cowpea plant indicated that there was a significant influence of soil moisture on the yield of cowpea as *P* value is less than 0.05 (Table 4). The obtained results showed that the yield of cowpea was greater under optimal moisture than sub-optimal. The highest reading observed was 4057.423 Kg/ha under optimal and the lowest was 221.046 Kg/ha under sub-optimal. It clearly shows that yield of cowpea plants reduced with reducing soil moisture. Daryanto *et al*. (2015) stated that drought-induced yield reduction is high in cowpea and green gram compared to other legumes. Reduction of yield under sub-optimal condition may be due to low productivity. This was clearly supported by Muchow (1985), who stated that limited water supply might impose a restriction on canopy development and productivity by influencing various physiological processes in legume plants. Reduction in pods per plant under sub-optimal level may also be a reason for the reduction in yield (Table 2). Lopez *et al*. (1996) stated that decrease in yield of grain legumes grown under drought conditions is largely due to the reduction in the number of pods per plant. The results pertaining to the yield of cowpea plant indicated that there was a significant influence of potassium rates on the yield of cowpea as *P* value is less than 0.05 (Table 4).

Table 4: Effect of soil moisture level and potassium rates on the yield of cowpea plant (Kg/ha)

	Yield(Kg/ha)	
Rate of MOP	Sub-optimal moisture	Optimal moisture
125%	268.16 ± 67.02^{b}	2727.99 ± 283.23^{b}
150%	1397.52 ± 398.64^{a}	2713.33 ± 277.78^{b}
175%	1513.81 ± 228.97^{a}	4057.42 ± 305.06^{a}
Recommendation	221.05 ± 112.16^{b}	1278.09 ± 161.38^{c}
	Moisture content	$P < 0.05$
	MOP	$P < 0.05$
	Interaction	$P < 0.05$

Means with dissimilar letters within the spacing are significant (p < 0.05).

Increasing potassium levels significantly increased the yield of cowpea. Under both moisture levels highest yield was observed at 175% potassium level. This may due to the highest seed weight per pod (Table 3). The interaction between the moisture level and potassium rates had a significant effect on yield. Especially, under sub-optimal condition significantly highest yield was observed at 150% and 175% potassium level compared to the recommended level. This may be due to the increased transmission of photo assimilates from leaves to pods with increasing level of potassium. This was supported by William (2008).

Conclusions

From the experiment, it would be possible to conclude that, among the combinations potassium rate at 175% of recommendation at optimal moisture level highly improved cowpea potassium content and yield. It also increased the potassium content and yield under sub-optimal moisture compared to recommended rate of potassium.

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IMPACTS OF BIOCHAR ON EROSION POTENTIAL OF SOIL IN SLOPE LAND

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Abstract

The study was conducted to evaluate the soil erosion potential in the slope land incorporated with biochar produced by *Pinus pinaster* (Pinus), *Eucalyptus tereticornis* (Eucalyptus) and *Camellia sinensis* (Tea). This study was conducted in Kandy district between latitudes 7.2906° N, 80.6337° E during 27th of August to 20th of November, 2017. There were sixteen plots of land prepared with the plot size of 1.5m x 2.0 mand each type of biochar made from pinus, eucalyptus and tea incorporated into the 5 cm top soilin each plotseparately. The Complete Randomized Design was used with four treatments such as soil with tea biochar, soil with eucalyptus biochar, soil with pinus biochar and the control with each of four replicates. At the bottom of these plots, a ditch was excavated and covered with polythene and collected the eroded soil once in two weeks after the incorporation of different biochar with soil. Duncan's multiple range tests were carried out using SPSS 25.0. The estimated soil losses in the plots with tea biochar, pinus biochar, eucalyptus biochar and control were 98.81g, 219.77g, 218.96g and 781.83 g respectively. There was a significant reduction in the rate of soil erosion in the plots with tea biochar as 2.74 $gm^{-2}week^{-1}$. Plots with pinus and with eucalyptus biochar had almost similar reduction in the soil erosion rate as 6.08 $gm^{-2}week^{-1}$ and 6.12 $gm^{-2}week^{-1}$ respectively while the erosion rate in the control plot recorded as 21.72 $gm^{-2}week^{-1}$. Hence, application of tea biochar as a soil amendment could be recommended to reduce the soil erosion significantly in slope land in the hilly area.

Keywords: Biochar, Sloppy lands, Soil erosion

Introduction

Soil degradation refers the decline in soil condition caused by its improper use or poor management. Erosion, hard setting and desertification affected the productivity of agricultural lands and threatened the world's food security (Qadir *et al*., 2013; Mandalandv and Sharda, 2013; Ziadatanda and Taimeh, 2013). Biochar is the carbon rich product obtained from biomass such as wood, manure or leaves, heated in a closed container with little or no available air. Biochar was used as a soil amendment (McElligott, 2011). Biochar using locally available and renewable materials improved soil fertility and nutrient use efficiency in a sustainable way (Lehman *et al*., 2009). Biochar had been considered as a material for suitable organic amendment for improving the physical properties and maintaining the fertility of soil, particularly for degraded soils in subtropical and tropical regions (Chan *et al*., 2007; Deenik *et al*.,

2011; VanZwieten *et al*., 2007). Hence, biochar may be a potential material for soil amendment that could protect the erosion of soil from rapid degradation in the long term, thus increasing the value and productivity of upcountry soils. Greater proportion of the micro pores was yielded a higher surface area, and thus greater nutrient retention capability (Warnock *et al*., 2007). Clay and Malo, (2012) reported that depending on the type and amount of biochar applied, the changes in soil properties associated with application as well as the physiochemical properties of the char itself, may impact the use, rates and efficacious properties (Lehmann *et al*., 2003). Numerous studies have indicated that biochar effectively improved soil structure (Atkinson *et al*., 2010; Jien and Wang., 2013), soil aggregate stability (Herath *et al*., 2013; Dimoyiannis *et al*., 2012; Cerda, 2000), and porosity (Lehmann *et al*., 2006) because of its high specific area and inner porous structure.

Biochar had the potential impact on sustainable soil management in regional levels. The contribution of biochar as a soil amendment was currently being assessed in two main aspects. One was related to its potential to enhance the productivity of agricultural systems and to combat land degradation by improving soil physical, biological, and chemical properties. Natural organic materials (e.g. green manure) and artificial polymers (e.g. polyacrylamides) had been used to ameliorate degraded soils (Busscher *et al*., 2011; Hueso-Gonz´alez *et al*., 2014). Maintaining the long-term aggregate stability of soils by applying fresh organic residues was difficult because of the rapid degradation of the traditional amendments (Busscher *et al*., 2011). In subtropical and tropical regions techniques such as retaining walls and shotcretes were commonly used to protect soil from erosion; however, these techniques were ineffective in in-situ condition (Chan *et al*., 2008). Therefore, the study was conducted to explore the effect of biochar on the erosion potential in slope land soil.

Materials and Methods

Biochar preparation

The biochar preparation was done according to the Hansen *et al*. (2011). A small one side open drum was taken. The center of the bottom and lid of the drum was determined and square shape cuts with length and width about 10 cm in each side were obtained. An iron bar was taken and drilled 2cm in diameter nozzles with 3 cm gaps in each side. Then the prepared iron bar was vertically inserted into the prepared metal drum. The bottom of the iron bar was reverted into bottom of the drum. Metal drum was filled with cut pieces of tea wood chips, pinus cones and eucalyptus barks separately. The lid was closed very tightly and the whole drum was placed on a rim. Firewood was applied to the upper open of the iron bar and burnt around 90 minutes. Pyrolysis process for the preparation of tea and eucalyptus biochar was taken 90 minutes whereas in pinus it was taken 120 minutes. After certain time the drum was allowed to cool and biochar was taken out to air dry. Finally, biochar was grained, sieved through mesh size of 2 mm sieve and packed into bags separately for the field application. The field was selected in Kandy district between latitudes 7.2906° N, 80.6337° E.

Land preparation and Biochar application

The land was prepared with the plot size of 1.5 m x 2.0 mfor soil erosion experiment with four treatments such as C (control), E (eucalyptus), P (pinus) and T (tea). Each plot had 0.5 m space with one another. Block was designed by considering slope gradient. At the bottom of these soil erosion plots, a ditch was excavated and covered with polythene in order to collect the eroded soil (Hellin, 2006). Each type of biochar was incorporated in to the top 5 cm soil with the application rate of 250gm^{-2}.The Complete Randomized Design was used with fourtreatments with four replicates.

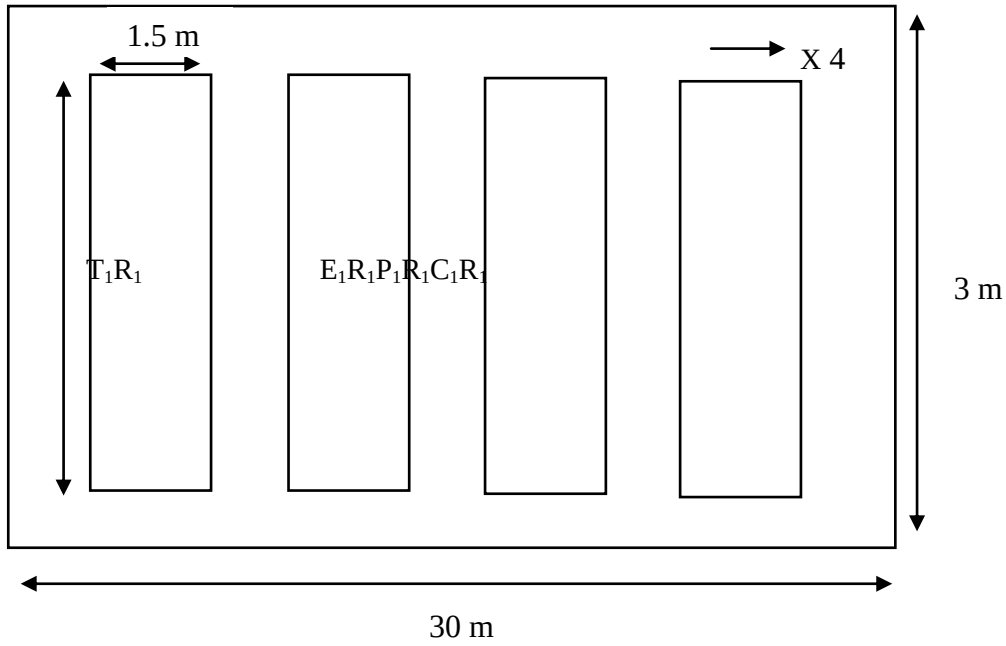

Figure 01: Detailed experimental layout for soil erosion measurements

Laboratory analysis for soil erosion

The soils samples from each plot were collected from the bottom ditches once in two weeks using small hoe. The collected samples were taken to the laboratory and allowed to air dry for three days. The weight of each sample was taken by using a digital balance (Hellin, 2006).

Statistical analysis

Means and standard deviation for all numerical data were calculated by using SPSS 25.0 statistical package. One-way ANOVA was used to analyze the collected data on eroded soil. Significant differences among treatment means were separated using Duncan's multiple range test at $\alpha = 0.05$ and confident interval (CI) = 95%.

Results and Discussion

Improvement of Soil Erosion Potential by biochar Application

The soil erosion experiment was done under the natural conditions and the average rainfall distribution data at the experimental site during the experimental period was presented in figure 2. Precipitation is received by both South –West monsoon and second inter monsoon. Rainfall due to South – West monsoon was lower than the rainfall of second inter monsoon. The average rainfall was recorded as 120.7 mm and average temperature was recorded as 22 $^{\theta}$C at the experimental site during the experimental period. The highest rainfall was recorded in October followed by November, 2017.

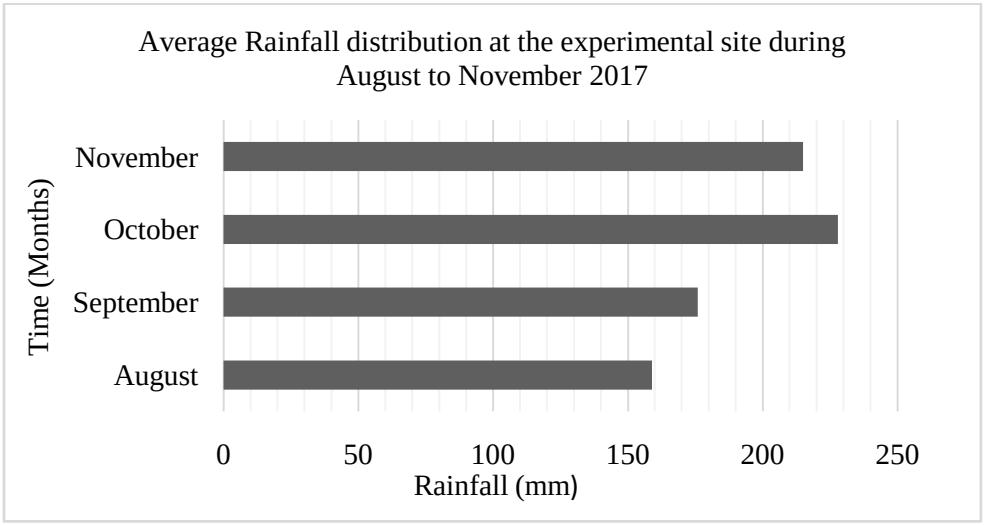

Figure 2: Average Rainfall distribution at the experimental site during August to November 2017

The results revealed that there was a significant difference between average weight of the eroded soil in the erosion plots of different treatments (P= 0.0000) over time (Table 1). According to results, at the end of the 12th week, weight of the eroded soilin the treated plots with biochar were highly reduced compared to the control. The overall soil loss was less in the plots of tea biochar followed by plots of pinus, eucalyptus biochar and control were 98.81g, 219.77g, 218.96g and 781.83 g respectively. The weight of the eroded soils in the control plots was increased with the high rainfall intensities during the months of October and November. Soils treated with pinus, eucalyptus and tea biochar plots had a less amount of soil erosion compared to the control plots.

Table 1: Variation of mean weight of eroded soils with biochar from different materials weekly

Weeks	*Control*	*Tea biochar with Soil*	*Eucalyptus biochar with Soil*	*Pinus biochar with Soil*
	g	*g*	*g*	*g*
2nd week	115.83 ± 1.70[a]	18.06 ± 0.67[c]	40.83 ± 0.82[b]	41.77 ± 1.17[b]
4th week	127.56 ± 1.78[a]	17.40 ± 0.46[c]	39.50 ± 0.53[b]	39.00 ± 0.62[b]
6th week	133.67 ± 0.29[a]	16.91 ± 0.38[c]	35.70 ± 0.22[b]	37.52 ± 0.16[b]
8th week	129.47 ± 0.14[a]	16.36 ± 0.34[c]	37.40 ± 0.19[b]	35.37 ± 0.23[b]
10th week	142.66 ± 0.26[a]	15.40 ± 0.16[c]	36.52 ± 0.33[b]	33.63 ± 0.29[b]
12th week	131.82 ± 1.21[a]	14.63 ± 0.18[c]	32.98 ± 1.17[b]	31.41 ± 0.19[b]

(Means with the same letter are not significantly different at $P < 0.05$ level based on Duncan's multiple range test)

The erosion rate was determined by the loss of soil per area of soil erosion plot ($3m^2$) per week. There was a significant reduction of soil erosion rate in the plots of tea biochar as 2.74 $gm^{-2}week^{-1}$. Plots of pinus and eucalyptus biochar had almost similar reduction in the soil erosion rate as 6.08 $gm^{-2}week^{-1}$ and 6.12 $gm^{-2}week^{-1}$ respectively while the erosion rate in the control plot recorded as 21.72 $gm^{-2}week^{-1}$.

Conclusions

Applying biochar as a suitable organic amendment can be effectively improves soil physical properties and reduces potential for erosion in slope lands in hilly area. Soil erosion was significantly decreased in biochar treated soils. Further the rate ofsoil erosion was greatly reduced in the plots applied with tea biochar. Meanwhile, biochar application could be expected to significantly reduce soil loss contents by 21.72 gm^{-2} $week^{-1}$ to 2.74 $gm^{-2}week^{-1}$. Hence, biochar may be a potential amendment that could protect from soil erosion in rapid degraded soils in the long term, thus increasing the value and productivity of the soils in hilly area.

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EFFECT OF INORGANIC POTASSIUM FERTILIZER AND SELECTED ORGANIC MANURES ON THE POTASSIUM AVAILABILITY AND YIELD OF COWPEA (*Vigna unguiculata*) IN SANDY REGOSOLS OF BATTICALOA DISTRICT, SRI LANKA

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Abstract

Potassium fertilization facilitates the crops to survive under drought condition and adding organic manures increases the soil moisture content in sandy soils. A pot experiment was carried out at Eastern University, Sri Lanka during the period of July to September 2018, to evaluate the effect of organic manures and different rates of inorganic potassium on the yield of cowpea (*Vigna unguiculata*) in sandy regosol using variety 'Wijaya'. There were eight treatments combining cow dung and compost with muriate of potash (MOP) at the rate of 100%, 125%, 150% and 175% of the fertilizer recommendation and were replicated three times in two factor factorial completely randomized design (CRD). Highest yield was recorded in compost applied treatments. Increasing rate of potassium increased the potassium uptake in plants. Highest yield was obtained at treatment consists of combination of compost with 175% of the recommended dosage of MOP. Therefore combination of compost with increasing rate of MOP can be suggested to farmers especially for the cultivation of cowpea on sandy regosols in order to obtain better yield.

Keywords: compost, cow dung, potassium, sandy soil, yield

Introduction

Sri Lanka has diverse soil types. Regosol is one of the major soil groups found in the dry zone of Sri Lanka It is found along or near the coastal line such as Kalpitiya, Nilavelly and most parts of Batticaloa district (Panabokke, 1996). Batticaloa district is one of the intensive agricultural area in the eastern province of Sri Lanka. According to the characteristics of the sandy regosol it is low in agricultural value and these soils are light sandy textured with very low cation exchange properties. Thereby their nutrient supplying capacity is very low (Imsamut and Boonsompoppan, 1999). In addition their water holding capacity and organic matter content is very low. Therefore proper management practices should be adopted to increase crop productivity.

As a result of climate change, drought is becoming a serious threat in Agriculture. Drought is a major factor limiting productivity in agriculture and have caused a collapse in food production by reducing uptake of water and nutrient (Du, *et al*., 2010). In Sri Lanka about 66% of crop lands are rain-fed (Biradar, *et al*., 2009) and therefore

increasingly vulnerable to the impacts of climate variability and extremes. So climate change impacts should be overcome by appropriate management strategies.

Pulses are important component of the Agricultural sector in Developing countries due to their significant capacity of protein rich seed production. Cowpea is an important leguminous crop grown in Sri Lanka. It is grown in both *Maha* and *Yala* season as mono and intercrop. It is used as green vegetables, pulses and also fodder. It plays an important role in human diet and has its importance in Agriculture for various cropping systems. Soil moisture is the principal environmental factor that limiting the legumes productivity in Tropical countries (De Costa, *et al*., 1999).

Potassium (K^+) is an essential element for plant growth. It is the most abundant cation in plants, and increasing plant's total dry weight by 3–5% (Marschner, 1995). This macronutrient is essential for many plant processes such as enzyme activation, protein synthesis, photosynthesis, osmoregulation during cell expansion, stomatal movements, solute phloem transport, electrical neutralization, regulation of membrane potential, transport of sugars, and the maintenance of cation–anion balance in the cytosol as well as in the vacuole (Maser, *et al*., 2002).

Drought is a significant limiting factor for agricultural productivity and generally inhibits plant growth through reduced water absorption and nutrient uptake. Decreased water availability generally results in reduced growth and final yield in crop plants. Potassium ions contribute significantly to the osmotic potential of the vacuoles even under drought conditions (Marschner, 1995). Plants adopted different mechanism to survive with the different stresses. The use of minerals plays an important role in plants resistance against the abiotic stresses. Among the nutrients, Potassium (K^+) plays an important role in growth and development and contributes significantly towards the plants survival under drought stress (Hassan, *et al*., 2017).

Water Holding Capacity of soil is controlled primarily by the number of pores and specific surface area of soil. Water Holding Capacity is increased when the number of small pores increases. Sandy soils have much less surface area than clay soils, thus retain less water at higher tensions. Addition of organic manures increases the specific surface area and resulting in increased Water Holding Capacity. Soil texture and organic manures are the key components that determine the soil water holding capacity and the water retain by the organic manure is used by the plants and this addition enhances plant growth and improves water use efficiency (Vengadaramana and Jashothan, 2012).

Climate change is one of the major challenge in Agriculture. Drought causes severe problems in cowpea cultivation in Eastern Region of Sri Lanka. Adding organic manures increases the water holding capacity and application of potassium reduces the moisture stress in cowpea (Hassan, *et al*., 2017). But the level of potassium and type and amount of organic manure can applicable to increase the yield performance of cowpea is scanty. The main emphasis here to determine the impact of type of organic manure, rate of potassium and their interaction effect on the yield of cowpea variety wijaya at drought condition.

Materials and Methods

Description of experimental site

A pot experiment was conducted during *yala* season (July to September 2018) at Eastern University, Sri Lanka, which is located in the low country, dry zone (DL2) agro ecological zone. The monthly average temperature and humidity were 30-36ºC and 66-81% respectively during the experiment period.

Description of soil and organic manures used in the experiment

The soil type used in this study was sandy regosol. It belongs to the group of Tropofluvents as per United States Department of Agriculture soil taxonomy (De Alwis and Panabokke, 1972). Initial potassium content of soil was analyzed using flame photometer and value was 0.026mg/kg soil. Organic manures used in this experiment were cow dung and compost and their available potassium contents were 0.67% and 0.53% respectively.

Treatments and experimental design

The treatments were evaluated to select the best combination of organic manure and rate of potassium to tolerate the drought condition in sandy regosol at Batticaloa region. The treatment combinations were laid out in two factor factorial Completely Randomized Design and there were eight treatments with three replicates. Cow dung and compost were used at the rate of 10 tons/ha and MOP was added at 100%, 125%, 150% and 175% of fertilizer recommendation for cowpea by the Department of Agriculture, Sri Lanka. The treatments were,

O1K0- cow dung + 100% MOP
O1K1- cow dung + 125% MOP
O1K2- cow dung + 150% MOP
O1K3- cow dung + 175% MOP
O2K0- compost + 100% MOP
O2K1- compost + 125% MOP
O2K2- compost + 150% MOP
O2K3- compost + 175% MOP

Planting

A bulk soil sample was collected from an area where cultivation was not previously carried out at 0-20 cm depth. The collected soil sample was processed and air dried for a day. Then it was sieved (2mm mesh sieve) to avoid the soil heterogeneity. Each polyethylene bag was filled with 7 kg processed soil. According to the treatments, organic manures and fertilizers were incorporated in to the soil 3 days prior to the planting. Pre-treated seeds were sown in each bag and two plants per bag were maintained.

Watering

Water holding capacity of sole soil and soil with organic manures were measured in volume basis. Watering was done according to the weight loss of individual treatments at two days interval to maintain the required water holding capacity.

Measurements

Manure analysis
Available potassium content of manures were extracted by triple acid and analyzed by flame photometric method (Toth and Prince, 1949).

Plant analysis
Potassium content of plants in each treatment were extracted by triple acid and analyzed by flame photometer.

Soil analysis
At harvesting potassium content of soil in each treatment were determined by flame photometer.

Yield
Mature cowpea pods were harvested and dry seeds weight were taken in each treatments.

Analysis of results
The data from experimental plants were statistically analyzed using Analysis of Variance (ANOVA) to detect if there was any significance at treatment level. The differences between treatment means were compared using Duncan's Multiple Range Test (DMRT) using SAS 9.1.3 package.

Results and Discussion

Potassium content in soil and plant at harvesting
Significantly ($p<0.05$) highest potassium content in soil was recorded at the combination of compost with 175% of the recommended dosage of MOP. Among the organic manures highest soil potassium content was observed at compost applied soil than cow dung. It could be due to the high exchangeable potassium content in compost than cow dung (Tanseem *et al*., 2004 and Hossein 2014). Compost also increases available form of nutrients in soil for plant (Soheil *et al*., 2012). Adugna (2016) stated that compared to cow manure, compost release nutrients more slowly and have longer lasting effects and the slow decomposition was more effective in increasing soil nutrient content. Among the rate of potassium highest potassium content in soil was observed at K3 followed by K2 and lowest was at K0. This statement was strengthen by AFL Sa *et al* (2014) and Tariq *et al* (2011). They found that increase of potassium content in soil was proportional to the increase of the doses of potassium fertilizer.

Table 1: Effect of potassium and organic manures on potassium content in soil and plant at harvest

Organic manure	Rate of Potassium (MOP)	K content in soil (mg/kg)	K content in plant (mg/kg)
Cow dung	K0 (100%)	45.886 ± 0.2569^{d}	2.635 ± 0.0349^{d}
	K1 (125%)	57.626 ± 0.1516^{c}	3.608 ± 0.0395^{c}
	K2 (150%)	65.286 ± 0.2028^{b}	4.212 ± 0.0105^{b}
	K3 (175%)	75.640 ± 0.1479^{a}	4.686 ± 0.0194^{a}
Compost	K0 (100%)	48.616 ± 0.1567^{d}	2.758 ± 0.0483^{d}
	K1 (125%)	60.930 ± 0.2432^{c}	3.820 ± 0.0335^{c}
	K2 (150%)	71.923 ± 0.1186^{b}	4.718 ± 0.0576^{b}
	K3 (175%)	80.773 ± 0.2390^{a}	5.105 ± 0.0600^{a}
	Organic manure	$P < 0.05$	$P < 0.05$
	MOP	$P < 0.05$	$P < 0.05$
	Interaction	$P < 0.05$	$P < 0.05$

The values are means of replicates ± standard error
Means at the same letter(s) in same column are not significantly different from each other according to the Duncan multiple range test at 5% significant level.

Significantly ($p<0.05$) highest potassium content in plant was measured at the combination of compost with 175% recommended dose of MOP. Among the organic manures highest potassium content in plant was observed at compost than cow dung and among the rate of potassium, highest plant potassium was observed at K3 and followed by K2. This might be due to the high concentration of potassium at K3 and compost applied soil. This statement was supported by Sunaga *et al.* (2015). They stated that potassium uptake of crops increased linearly with increased rate of potassium application. Tariq *et al.* (2011) found that increase rate of potassium increase the potassium content in both soil and plant. Abdel and Salem (2012) reported that addition of organic manures increased the potassium uptake.

Yield

Significantly ($p<0.05$) highest yield was recorded at the combination of compost with 175% recommendation of MOP. Among the organic manures highest yield was obtained in compost than cow dung. This is strongly supported by Adugna (2016). He reported that compared to cow manure, composts release nutrients more slowly and have longer lasting effects and the slow decomposition is more effective in increasing soil organic matter content of the soil, which plays a key role in soil fertility by retaining nutrients, maintaining soil structure and water holding capacity.

Table 2: Effect of potassium and organic manures on the yield of cowpea

Organic manure	Rate of Potassium (MOP)	Yield (kg/ha)
Cow dung	K0 (100%)	1552±22.663[c]
	K1 (125%)	1973±146.20.1[c]
	K2 (150%)	2734±356.959[b]
	K3 (175%)	3514±249.180[a]
Compost	K0 (100%)	2098±208.067[b]
	K1 (125%)	2317±224.783[b]
	K2 (150%)	3405±232.446[a]
	K3 (175%)	3960±454.719[a]
	Organic manure	$P < 0.05$
	MOP	$P < 0.05$
	Interaction	$P > 0.05$

The values are means of replicates ± standard error
Means at the same letter(s) in same column are not significantly different from each other according to the Duncan multiple range test at 5% significant level.

Potassium plays an imperative role in the photosynthesis process and the subsequent carbohydrate translocation and metabolism, which eventually increase the crop yield and improve the grain quality (Pettigrew, 2008; Lu *et al*. 2016). Bednarz *et al*. (1998) reported that potassium controls photosynthesis through sunlight interception and leaf surface area and sunlight interception were both reduced dramatically when the potassium was below the level required by the plant. Zhao *et al* (2001) stated that the photosynthesis rate in plants increased with the higher utilization and export of photo assimilates and the sucrose level in the leaves was increased when the plants were supplied with a sufficient level of potassium. And also potassium regulates the biosynthesis, conversion, and allocation of metabolites that ultimately increases the yield. Islam and Muttaleb (2016) reported that potassium helps to increase the nitrogen uptake as well as nitrogen use efficiency that help in increasing the yield of rice.

Conclusions

From this study it was concluded that highest yield was recorded at the combination of compost with 175% of the recommended dosage of MOP as Potassium. Also combinations of 175% recommendation of MOP with compost and cow dung were improved the soil potassium content, plant potassium content and yield of cowpea.

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PERCEPTION OF CLIMATE CHANGE AND ITS EFFECT ON HUMAN HEALTH: A PRELIMINARY SURVEY AMONG THE STAFF AT EASTERN UNIVERSITY, SRI LANKA

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Abstract

Climate change has been a global issue and Sri Lanka is no exception. The projected temperature rise rainfall change impact on crops yield and human health are at alarming levels along with natural disasters. Awareness on minimizing the adverse climate change to mitigate becomes mandatory. This preliminary study among the employees of Eastern University, Sri Lanka (EUSL) aims at analyzing their perception with regard to the climate change, happening in their living vicinity. A number of fifty four staff volunteered to enroll in this study. A pre-tested questionnaire was used to gather data through statements with five point Likert scale and analyzed using descriptive statistics and chi-square-goodness of test. Among the participants 43 (80%) has educational qualifications GCE Advanced level or beyond and 61% were holding the intermediate position. 61.1% responded that there has been high level of change in the climate in their living environment during last ten years with regard to the increase of heat and low rainfall . The result was statistically significant for chi-squared-goodness- of-fit test ($p<0.05$). With regard to the crop production in recent years, the response was that 37% said no change in yield of agricultural crops while 57.4% said reduction in the yield ($p<0.05$). Majority, (85.1%) responded increase in the illnesses in recent years and illness such as Dengue, Bronchial asthma and common cold were the most common illnesses. The participants opinions regarding the steps taken to minimize/mitigate climate change were categorized into three topics such as Preservation of nature, Control of greenhouse gas emission and Making awareness among public. Majority of the participants prefer to know more on the climate change issues. The study thus concludes that the staff in the study are well aware on the ill effects of the climate change on the environment, crops yield and human health, measures to be taken to minimize them and prefer further training indicating that climate change education should need to be an agenda in university activities.

Keywords: Climate change, Crop production, Human health, Staff perception, Yield of agriculture.

Introduction

Climate change has been a global issue and Sri Lanka is no exception. It appears that the climatic parameters are gradually worsen in Sri Lanka along with global trend. The second national commission on climatic change report that during the 40 years period from 1961-2000, revealed that temperature increase of minimum of 0.27ºC and maximum of 0.46ºC per decade had been noted in Sri Lanka (Ministry of Environment, 2011). As per the World Health Organization (WHO) report, the mean annual temperature of Sri Lanka is expected to rise by 3.7ºC from 1900 to 2100 under the high emission scenario (WHO, 2015). The projections of rainfall also changes which may lead even to change the demarcation of dry and wet zone with reduction in the land area of wet zone. It has also been projected that an annual average of 65,600 people will be affected by sea level rise between 2070 and 2100 (Ministry of Environment, 2011).

As projected, drought, floods, storm surges, increased rainfall variability, landslide, sea erosion and related crop destruction are the regular occurrences for the last two decades in Sri Lanka which might be the result of direct and indirect impacts on climatic condition. These direct and indirect effects ultimately have impact on agriculture and food security, loss of water resources and finally affect the economy of the county.

Apart from the effect of climate change on economy and property, impact of climate change on health system has also been reported by researchers. As noted by the WHO, the climate change not only affects the biological system but also pose 'significant and emerging threat to public health' particularly in low income countries (Dunlap and McCright, 2008; IPCC, 2001). The increased temperature may also lead to spread of vector borne diseases especially the disease like Dengue which is spread by Mosquito. Further, the polluted water, extreme weather events also increase the risk of vector-borne, rodent-borne, food and water borne diseases (Ministry of Environment, 2011).It has been predicted that diseases such as malaria and dengue will increase towards 2070 under both high and low emissions scenarios and likewise, elderly death has been predicted to increase 22 deaths/100,000 by 2080 (WHO, 2015).

In this context, it is essential to study the public perception of effect of climate change which would help designing specific programs on this issue. There are several similar studies both in developed (DeBono *et al*., 2012; González and Da Silveira, 1997; McMichael and Butler, 2006; Preet *et al*., 2010) and developing countries (Chaudhary and Bawa, 2011; Emch *et al*., 2008; Haque *et al*., 2012; Toan *et al*., 2014) in this regard.

Objectives of the study

This study aims to analyze the perception of the staff working at Eastern University, Sri Lanka (EUSL) with regard to the climate change, happening in their living vicinity.

Specific Objectives

- To analyze perception of staff on the climate change in their surroundings

- To analyze the perception of staff on the impact of climate change on health
- To analyze knowledge of staff on the steps to be taken to minimize or mitigate climate change.

Methodology

This study was a cross sectional survey design among randomly selected minor, intermediate and executive level staff of Eastern University, Sri Lanka (EUSL) conducted in the months of August and September 2018. A self-administrated questionnaire was developed based literatures and was tested using a pre-test format among ten staff member of EUSL, who have not been included in the data collection. The final self-administrated questionnaire was then administered among those who were willing to participate in the study. Informed consent was obtained from the participants and approval to conduct this study was obtained from the Vice Chancellor of the university. The data was analyzed using descriptive statistics and chi-square-goodness of test.

Results and Discussion

A number of fifty four employees participated in the study. Out of the total number of participants 43 (80%) has educational qualifications GCE Advanced level or beyond. Thirteen of them were in the executive officers' category (24%), 33 were intermediate level (61%) and 8 (15%) were minor employees. The summary of demographic characteristics of study subjects is given in Table 1.

Table 1: Demographic characteristics of study population

		Frequency (%)
Gender	Male	32 (59.3%)
	Female	22 (40.7%)
Age (years)	20-30	11 (20.4%)
	31-40	17 (31.5%)
	41-50	17 (31.5%)
	51-60	9 (16.7%)
Educational Qualification	Up to G.C.E Ordinary Level	11 (20.4%)
	G.C.E Advanced Level	19 (35.2%)
	Diploma/Degree	19 (35.2%)
	Post graduate	5 (9.3%)
Type of Job	Minor employee	8 (14.8%)
	Intermediate employee	33 (61.1%)
	Executive employee	13 (24.1%)

Perception on Climate Change

Perception of climate change had been collected through four statements with five point Likert scale (Table 2). Among the participants, 61.1% responded that there has been high level of change in the climate in their living environment during last ten years. The result was statistically significant for chi-squared goodness of fit test ($p<0.05$). Regarding the amount of heat during summer when compared to last 5-10 years, the 61.1% responded that there has been high level of increase and 31.5% responded very high level of increase ($p<0.05$). In relevant to this result, 77.8% reported that there has been high level of drought ($p<0.05$). With regard to the amount of rainfall, majority of the respondents perceived reduction. Among the respondents, 61.1% reported that low level of rainfall and 13% reported very low level of rainfall ($p<0.05$). With regard to the crop production in recent years, the response was that 37% said no change in yield of agricultural crops while 57.4% said reduction in the yield ($p<0.05$).

Table 2: Perception of climate change

Statements regarding perception of climate change	Percentage of response					P value
	Very low	Low	Normal	High	Very high	
Degree of change in the climate of our environment during last 10 years	3.7	1.9	25.9	61.1	7.4	0.00
Degree of severity of heat during summer when compared to last 5-10 years.	1.9	1.9	3.7	61.1	31.5	0.00
Amount of rainfall when compared to past	13.0	61.1	14.8	11.1	0.0	0.00
Degree of drought in recent years	0.0	5.6	7.4	77.8	9.3	0.00
Amount of yield of agriculture in recent years	13.0	44.4	37.0	3.7	1.9	0.00

Perception on impact of climate change on health

Perception of the impact of climate change on human health had been collected through two statements with five point Likert scale (Table 3). Among the participants 70.4% responded that people contracting illnesses had been at high level during summer and 68.5% responded that high level of illness during rainy season ($p<0.05$).

Table 3: Perception on the health impact of climate change

Statements	Percentage of response					P value
	Very low	Low	Normal	High	Very high	
Disease condition in summer after 2013	0.0	1.9	24.1	70.4	3.7	0.00
Disease condition during rainy session after 2013	0.0	3.7	14.8	68.5	13.0	0.00

With regard to the overall opinion about the illnesses contracted due to the climate change, 85.1% responded increase in the illnesses while 8.5% responded decrease and 6.4% responded no change. According to the respondents, majority of them reported

that Dengue, Bronchial Asthma, Common cold and skin diseases are disease which had been increased due to the climatic change in their surroundings (Table 4).

Table 4: Highest prevailing disease due to climate change, according to respondents

Disease conditions	%	Disease conditions	%
Dengue	98.1	Kidney infection	44.4
Asthma	85.2	High blood pressure	42.6
Common cold	83.3	Malaria	40.7
Skin disease	70.4	Diabetes	27.8
Eye disease	64.8	typhoid	25.9
Kidney related disease	51.9	Encephalitis	9.3
Allergic	50	Stroke	5.6

For the question "Do you need training on the issues of climate change", 88% of the participants responded 'yes'. The respondents' knowledge on measures to mitigate the manmade climate change was analyzed through qualitative question (What are measures which can be taken individually or collectively to mitigate the manmade climate change?). Their response can be categorized into three topics such as Preservation of nature, Control of greenhouse gas emission and Making awareness among public. The opinions of respondents among these three topic is summarized in the table 5. Over 90% opinioned on the prevention of deforestation and control of greenhouse emission by vehicle fuel. However few respondents believe that the climate change cannot be controlled but we can minimize the effect. One such response was *"Climate change is a natural process which cannot be controlled. However, we can minimize the effect of climate change by good housekeeping of surrounding, not erect building in landslide prone area, prevent deforestation, encourage reforestation, control sand excavation, and maintain water ways and canals to ensure free flow of water".*

The opinions also consisted of other kind of pollution controls as well which are not directly involved in climate change. The qualitative analysis shows that the respondents have satisfactory knowledge on the climate change.

On overall analysis this study involves university employees' perception in the changes of climate of their living vicinity, effects on health and agricultural yields; all these have direct impacts on their living conditions. Results show statistically significant impacts on the temperature and rainfall patterns, contracting illnesses mainly infectious diseases and respiratory illnesses. With regard to the yield of agriculture crops 37% of the staff feels no change is to be taken into account. This perception could be due to the fact that people engage in crop productions such as home gardening and other activities such as use of organic fertilizers.

Table 5: Respondents' Opinion on measures to mitigate the manmade climate change

Category of topic	*Opinion of Respondents*
Preservation of nature	• *Prevent the deforestation* • *Encourage the reforestation* • *Encourage the home gardening* • *Control the land filling at wetland and erecting building*
Control of greenhouse gas emission	• *Reduce the use of fossils fuels* • *Decrease the fuel engine usage* • *Use of efficient engines* • *Control fuel vehicle and encourage the use of electric and hybrid vehicle* • *Control vehicle emission* • *Control the importance of vehicle* • *Encourage the importation of electric vehicle* • *Prevent the burning of waste* • *Avoid burning of waste instead of dumping* • *Manage properly the factory waste to control the greenhouse gas emission* • *Efficient use of electricity* • *Control the ozone depleting gas emission* • *Control the use of refrigerator* • *Encourage the use of solar panel* • *Encourage the use of biogas*
Making awareness among public	• *Make awareness about the benefits of reforestation* • *Forming voluntary groups to prevent deforestation* • *Make public awareness regarding deforestation, reforestation, setting forest fire*

The opinions of the staff on the measures to be taken to minimize or mitigate climate change indicate that they are well aware of the manmade disasters to the environment and thus reforestation by tree planting activities, minimize landfilling, reduce fossil fuels and increase use of renewable energy sources (solar panels), and waste management. The staffs of EUSL involved in this study advocate on increasing the public awareness on these issues and also on forming voluntary groups to do the identified tasks such as reforestation, public awareness programs etc. They themselves too feel requiring to know more on climate change indicate that they understand the importance on this global issue which would have a direct impact on our future generation.

Conclusions

This preliminary study show that significant proportion of the staff of EUSL participated in this study was in affirmation of the climate change in their living environment. A significant proportion of staff (92.6%) perceived that there has been a

high and very high level of increase in temperature while 74% of perceived that low and very low level of rainfall in their surroundings. They also have a mixed perception with regard to yield of agricultural crops and 57.4% of them stated that there is a reduction in crop production. Majority of them (85.1%) responded that the climate change has significantly increased the illness level in their surroundings and among them 70.4% of responded that people contracting illnesses had been at high level during summer and 68.5% responded that high level of illness during rainy season. The majority of respondent stated that Dengue (98.1%), Asthma (85.2%), common cold (83.3%) and skin diseases (70.4%) are most prevailing diseases in their surroundings, due to climate change. According to the qualitative analysis, their responses for the measures to mitigate the manmade climate change can be considered into three categoury such as measures to preserve of nature, measures to control the greenhouse gas emission and ways to make awareness among public. These responses indicate satisfactory level of awareness among respondents. Even though there quite majority of the respondents' responses consist of other kind of pollution controls which are not directly involved in climate change, 90% of them opinioned on the prevention of deforestation and control of greenhouse emission by fuel vehicle as measure to mitigate the made climate change. A majority of them (88%) prefer to know more on the climate change and training on mitigating indicates that climate change education should need to be an agenda in university activities. This study is a part of ongoing study on the perception climate among general public at Batticaloa district, so that it has small sample size among the staff of Eastern University, Sri Lanka. However, the findings further suggest to start awareness programme on climate change initially among the staff of Eastern University and to expand to general public.

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ANTIBACTERIAL ACTIVITY AND PHYTOCHEMICAL PROPERTIES OF SOME SELECTED MEDICINAL PLANTS FROM BATTICALOA DISTRICT

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Abstract

Plants as a source of medicinal compounds have continued to play a dominant role to maintain the human health. This study was carried out to investigate the antibacterial activity and phytochemical properties of some selected medicinal plants, namely, *Erythrina variegata, Adhatoda vasica* and *Ocimum sanctum*. All the leaf samples were collected from different localities of Batticaloa district, Sri Lanka.The acetone and ethanol extracts of leaf samples at the concentrations of 25, 50 and 75mg/100µl were tested for phytochemical properties and antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*, using well diffusion method. The highest inhibitory effect on *E. coli* and *S.aureus* was produced by ethanol extract of the tested leaf samples. The highest inhibitory effect was observed at all three concentrations of *Ocimum sanctum* against both bacteriafollowed by *Erythrina variegata*. The ethanolic extract of *Adhatoda vasica* showed the least antibacterial activity (16.8±0.7mm) against *S.aureus* and the *E.coli* (15.8±0.7mm) at 75mg/100µl concentration.The results of the qualitative analysis of phytochemicals revealed that alkaloids, saponins, flavonoids and tannins were present in ethanol and acetone extracts of *Ocimum sanctum*.Saponin, flavonoids and tannins were found in the acetone and ethanol extracts of *Erythrina variegate.* Saponin and tannins were found in the acetone and ethanol extracts of *Adhatoda vasica* and flavonoids were found in the ethanol extract of *Adhatoda vasica.*

Keywords: Medicinal plants, Antibacterial activity, phytochemicals, *Escherichia coli*, *Staphylococcus aureus*

Introduction

Plants have not only nutritional value but also, medicinal, ritual and magical values (Compean and Ynalvez, 2014). Majority of the population, especially those living in rural areas depends largely on medicinal plants for treatment of diseases (Pekamwar *et al*., 2013). They play an important role in health care, about 80% of the world's population rely on traditional medicines for their primary health care (Muthukrishnan *et al.*, 2014). The medicinal properties of plants may be based on the antioxidant, antimicrobial antipyretic effects of the phytochemicals (Pradhan *et al.*, 2015). Plants are producing a diverse range of bioactive molecules, making them rich source of different types of medicines (Hussain *et al.*, 2010).

This study too was aimed to determine (i) the antibacterial activity of some selected medicinal plants namely, *Erythrina variegata, Adhatoda vasica* and *Ocimum sanctum*, by determining the zone of inhibition of leaf extracts against *Escherichia coli* and *Staphylococcus aureus* and (ii) tostudythe phytochemical constituents of the leaf extracts of these three medicinal plants, qualitatively.

Materials and Methods

Collection of leaf samples

Ocimum sanctum and Adhatoda vasica were collected from the home garden at Chenkalady. *Erythrina variegata* was collected from the paddy fields of the same area. All samples were collected on the same day. The identification of these plant samples was done at the Department of Botany, Eastern University, Sri Lanka.

Preparation of leaf extracts

The leaves were washed thoroughly with tap water to remove associated debris followed by sterile distilled water. Then each leaf part was cut into small pieces (1-2 cm) to make it suitable for grinding. Then leaves were dried under shaded condition at room temperature until obtained constant weight. Completely dried leaves were crushed into fine powder using grinding machine. Powder was stored at room temperature in light airtight bottle until further usage. The resulting powders were extracted by two different solvents as described below.

Preparation of acetone and ethanol extract

20 g powder of each leaf was separately soaked in 60 ml of ethanol in airtight conical flask for two days on an orbital shaker, and then they were first filtered through double layered Muslin cloth followed by Whatman No 1 filter paper. The filtrates were collected into airtight bottles. Similar process was repeated twice with fresh ethanol and the filtrates were pooled together. Finally, ethanol was removed from the filtrates at 40^{o}C in an oven. The resulting extracts were then stored into refrigerator until use for further study (Jeyaseelan *et al.*, 2012). The similar method was followed to obtain the acetone extract too.

Phytochemical analysis

The phytochemical screening of the sample was carried out by using the standard qualitative procedures as mentioned in literature (Trease and Evans, 1989).

a) Alkaloids

One milliliter of 1% HCl was added to the 3 ml of leaf extract into test tube and was treated with few drops of Meyer's reagent. A creamy white precipitate indicated the presence of alkaloids.

b) Glycosides

Ten milliliter of 50% H_2SO_4 was added to the 1 ml of leaf extract into the boiling tube. The mixture was heated in boiling water bath for 5 minutes. 10 ml of Fehling's solution

(5 ml of each solution A and B) was added and boiled. A brick red precipitate indicated the presence of glycosides.

c) Flavonoids

A few drops of 1% NH_3 solution was added to the 2 ml of leaf extract into the test tube. A yellow coloration was observed for the presence of flavonoids.

d) Saponins

Five milliliter of leaf extract was shaken vigorously to obtain a stable persistent froth. The frothing was then mixed with 3 drops of olive oil and observed for the formation of emulsion, which indicated the *presence of saponins.*

e) Tannins

To 0.5 ml of leaf extract solution, 1 ml of distilled water and 1-2 drops of ferric chloride solution were added and observed for brownish green or a blue-black coloration.

f) Phlobatannins

Ten milliliter of leaf extract was boiled with 1% HCl in a boiling tube. Deposition of a red precipitate indicated the presence of phlobatannins.

g) Terpenoids

Five milliliter of extract was mixed with 2 ml of $CHCl_3$ into the test tube. 3 ml of concentrated H_2SO_4 was carefully added along the wall of the test tube to form a layer. An interface with a reddish-brown coloration was confirmed the presence of terpenoids.

h) Cardiac glycosides

Five milliliter of leaf extract was mixed with 2 ml of glacial acetic acid containing 1 drop of $FeCl_3$.The above mixture was carefully added to the 1ml of concentrated H_2SO_4. Presence of cardiac glycosides was detected by the formation of brown ring.

i) Anthraquinones

Leaf extract was mixed well with benzene, and then half of its own volume of 10% ammonia solution was added into that. Presence of a pink, red or violet coloration in the ammonial phase indicated the anthraquinones.

Testing the antibacterial activity

Escherichia coli (*E.coli*) and *Staphylococcus aureus* (*S.aureus*) were used to test the antibacterial activity of the leaf samples. Both pure cultures were obtained from Microbiology lab, Teaching hospital, Batticaloa. These bacteria were stored on nutrient agar slope at 4 ºC and they were sub cultured before using.

Leaf sample preparation

The test concentration of 25, 50 and 75mg/100µl were prepared using the solvent of ethanol and acetone separately.

Assessment of antibacterial activity

A well diffusion method was used to test the antibacterial activity of ethanol and acetone extracts of the different plant leaves. Briefly 25ml of autoclaved nutrient agar was cooled down to 40 ºC and poured into a sterile petri dish allowed to set. 18 nutrient agar petri dishes were prepared for three different type of leaf extracts of each solvent and each bacterium. Totally 72 nutrient agar petri dishes were prepared and was repeated 6 times.

Bacterial suspension (1×10^6cells/ml) were taken from serial dilution by using hemocytometer and 0.1ml of bacterial suspension was spread on the media plates, by sterilized glass spreader. Wells with 8mm diameter were filled with 100µl of each concentration of acetone and ethanol extracts, separately. Streptomycin (25µg/100µl) was used as positive control. 100µl of acetone and ethanol extracts were used as negative control. The plates were incubated at 37 ºC for 24 hours, and the antibacterial activity was determined by measuring the diameter of clear inhibition zone around the well.

Statistical analysis

Diameter of inhibition zone resulted from replicates were expressed as mean ± standard deviation (SD). The data were analyzed by one-way analysis of variance (ANOVA, P value < 0.05) using statistical software, MINITAB 14 system.

Results and Discussion

Collection of leaves of the medicinal plants

Adhatoda vasica
(Adathodai)

Erythrina variegate
(Mulmurukkai)

Ocimum sanctum.
(Thulasi)

Phyto-chemical screening

The qualitative test for the presence of phytochemicals showed the presence of different types of phytochemicals in ethanol and acetone extracts of selected medicinal plants. Solvents, used for the extraction, play a significant role in the solubility of the active principles of plant materials influence on the antibacterial activities of the extracts (Jeyaseelan *et al.*, 2010).

Phytochemicals in acetone and ethanol extractions

The results of the qualitative analysis of phytochemicals revealed that alkaloids, saponins, flavonoids and tannins were present in ethanol and acetone extracts of

Ocimum sanctum.Saponin, flavonoids and tannins were found in the acetone and ethanol extracts of *Erythrina variegate.* Saponin and tannins were found in the acetone and ethanol extracts of *Adhatoda vasica* and flavonoids were found in the ethanol extract of *Adhatoda vasica* (Table 1).

Table 1: Qualitative analysis of phytochemicals the leaf samples.

Phytochemicals	*Adhatoda vasica*		*Erythrina variegate*		*Ocimum sanctum*	
	Acetone	Ethanol	Acetone	Ethanol	Acetone	Ethanol
Glycosides	-	-	-	-	-	-
Alkaloids	-	-	-	-	+	+
Saponins	+	+	+	+	+	+
Flavonoids	-	+	+	+	+	+
Tannins	+	+	+	+	+	+
Terpenoids	-	-	-	-	-	-
Cardiac glycosides	-	-	-	-	-	-
Phlobatannins	-	-	-	-	-	-
Anthraquinones	-	-	-	-	-	-

(+) Presence or (-) Absence of phytochemical

Antibacterial activity

As shown in table 2, the inhibition zone increasd with concentration of leaf extract in acetone. The acetone extract of all three leaf samples showed the inhibitory effect to *E.coli* at 75 mg/100µl but there was a significant difference in level of antibacterial activity among the three types of leaf samples. The *E.coli* showed most susceptibility to the acetone extract of *Ocimum sanctum* at 75 mg/100µl.*Erythrina variegata* exhibited moderate effect to the *E.coli* and the *Adhatoda vasica* showed the least inhibitory effect at this concentration.

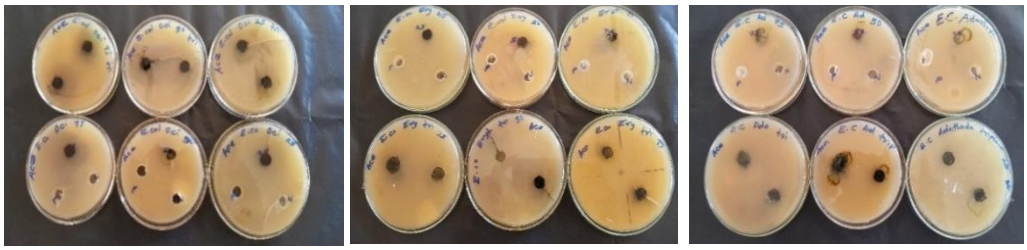
Table 2: Mean Diameter of inhibition zones, caused by acetone extract of leaf samples against *E.coli* at different concentrations

Plant samples	Concentration (mg/100µl)		
	25	50	75
Adhatoda vasica	-	-	9.2 ± 0.4^{d}
Erythrina variegata	-	-	10.7 ± 0.5^{c}
Ocimum sanctum	10.3 ± 0.5^{c}	12.7 ± 0.5^{b}	16.8 ± 0.4^{a}
Streptomycin (25µg/100µl)		28.3±0.5	
Acetone		-	

Values are diameter of zone of inhibition in mm (Mean± SD), (-) No activity, values with different superscripts are significantly (P<0.05) different.

As per the study by Sheeba and Mohan (2012), the acetone extract of *Adhatoda vasica* (100µg-500µg) was able to inhibit the growth of *E.coli*. However, the present study showed that acetone extract of *Adhatoda vasica* inhibited the *E.coli* at 75 mg/100µl but no inhibition zones were observed at 25 mg/100µl and 50 mg/100µl (Plate 1).

According to Seleman and Amri (2015), acetone extraction of *Ocimum sanctum* had the ability to inhibit the growth of *E.coli*. The present study also showed that acetone extraction of *Ocimum sanctum* highly inhibited the *E.coli* even at the concentration of 25 mg/100µl.



Ocimum sanctum *Erythrina variegata* *Adhatoda vasica*

Plate1: Inhibition zones of acetone extracts of *Ocimum sanctum, Erythrina variegata* and *Adhatoda vasica* against *E.coli* in, at 25, 50 and 75 mg/100µl

The results revealed that the inhibitory effect increased with the concentration, as the diameter of inhibition zones increased with the concentrations of ethanol extracts, tested (Table 3). Also, a significant difference ($P<0.05$) was observed in the inhibitory effect among different concentrations.

Table 3: Mean Diameter of the inhibition zones, caused by ethanol extract of leaf samples against *E.coli* at different concentrations

Plant samples	Concentration (mg/100µl)		
	25	50	75
Adhatoda vasica	11.2 ± 0.7^{m}	13.3 ± 0.5^{ij}	15.8 ± 0.7^{ef}
Erythrina variegata	12.3 ± 0.5^{kl}	14.3 ± 0.5^{gh}	18 ± 0.6^{bc}
Ocimum sanctum	12.7 ± 0.5^{jk}	14.8 ± 0.4^{g}	18.8 ± 0.4^{b}
Streptomycin (25µg/100µl)		29.3±0.5	
Ethanol		-	

Values are diameter of zone of inhibition in mm (Mean± SD), (-) No activity, values with different superscripts are significantly (P<0.05) different.

As per the study by Sheeba and Mohan (2012) that ethanolic extract of *Adhatoda vasica* (100µg and 200µg) did not show the inhibition of growth of *E.coli* and it was able to inhibit the growth of *E.coli* at 300µg to 500µg level. However, the present study showed that ethanol extract of *Adhatoda vasica* inhibited the growth of *E.coli* at the concentration of 25mg/100µl. According to Seleman and Amri (2015), ethanol extraction of *Ocimum sanctum* had the ability to inhibit the growth of *E.coli.* The present study also showed that ethanol extraction of *Ocimum sanctum* inhibited the *E.coli* even at low concentration, tested (25 mg/100µl).

Anti-bacterial activity of acetone extract against *S.aureus*

As shown in Table 4, the inhibition zone increased with the concentrations. Acetone extracts of leaf samples exhibited significant difference (P<0.05) against *S.aureus* among different concentrations. *Erythrina variegata*wasable to inhibit the growth of *S.aureus* effectively at all three concentrations (Plate 3).There is a significance difference between the acetone extracts of leaf samples at all concentrations. *Adhatoda vasica,* showed that the least inhibitory effect to the *S.aureus* bacteria at all concentrations (Table 5).

Table 4: Mean diameter of inhibition zones, caused by acetone extract of leaf samples against *S.aureus* at different concentrations

Plant samples	Concentration (mg/100µl)		
	25	50	75
Adhatoda vasica	9.2 ± 0.4^{n}	12.2 ± 0.4^{ij}	15.3 ± 0.5^{f}
Erythrina variegata	11.5 ± 0.5^{k}	15.2 ± 0.4^{fg}	18.2 ± 0.4^{b}
Ocimum sanctum	11.2 ± 0.4^{kl}	15.2 ± 0.4^{fg}	17.2 ± 0.4^{c}
Streptomycin (25µg/100µl)		34.7±0.5	
Acetone		-	

Values are diameter of zone of inhibition in mm (Mean± SD), (-) No activity, values with different superscripts are significantly (P<0.05) different.

As per the study by Wankhede (2015) that acetone extracts of *Adhatoda vasica* inhibited the growth of *S.aureus*. The present study also exhibited that acetone extract of *Adathoda vasica* inhibited *S.aureus* at the lowest concentration tested. The present study also exhibited that acetone extraction of *Ocimum sanctum* inhibited the *S.aureus* effectively at all three concentrations.

Anti-bacterial activity of ethanol extract against *S.aureus*

The inhibitory effect of ethanol extract of leaf samples against *S.aureus* at different concentrations are shown in Table 4. The inhibition zone increased with the concentration of ethanol extract of leaf samples and there was a significant difference (P<0.05) in the inhibitions zones against *S.aureus* among different concentrations. *O. sanctum* more effectively inhibited the *S.aureus* at all three concentrations.

Table 5: Antibacterial activity of ethanol extract of leaf samples against *S.aureus* at different concentrations

Plant samples	Concentration (mg/100µl)		
	25	50	75
Adhatoda vasica	12.8 ± 0.4^{k}	14.5 ± 0.5^{ij}	16.8 ± 0.7^{ef}
Erythrina variegata	12.3 ± 0.5^{lm}	15.2 ± 0.4^{gh}	19 ± 0.6^{c}
Ocimum sanctum	12.8 ± 0.4^{k}	15.3 ± 0.5^{g}	20.3 ± 0.5^{b}
Streptomycin(25µg/100µl)		35±0.8	
Ethanol		-	

Values are diameter of zone of inhibition in mm (Mean± SD), (-) No activity, values with different superscripts are significantly (P<0.05) different.

A significant difference in the antibacterial activity among the leaf samples extracts at all three concentrations. *Erythrina variegata* exhibited moderate effect to the *S.aureus*. *Adhatoda vasica,* showed that the least inhibitory effect to the *S.aureus* at all concentrations (Plate 4). The standard antibiotic streptomycin showed higher inhibitory effect on *S.aureus* than *E.coli*. As per the study by Wankhede (2015), the ethanol extract of *Adhatoda vasica* (100µg-500µg) was able to inhibit the growth of *S.aureus* and ethanol extract inhibited higher level than acetone extract.

Conclusions

As per this study, *Adhatoda vasica, Erythrina variegata* and *Ocimum sanctum*of acetone and ethanol extract were found to have antibacterial effect against *Escherichia coli* and *Staphylococcus aureus*. Among the both tested bacteria, *Staphylococcus aureus* was more sensitive to all leaf extracts than *Escherichia coli*. The qualitative analysis of phytochemical showed that alkaloids, saponins, flavonoids and tannins were present in ethanol and acetone extracts of*Ocimum sanctum*. Saponins and tannins were found in both extracts of all tested medicinal plants. Thus, it could be concluded that the medicinal plants used in this study consist antibacterial effect against *Escherichia coli* and *Staphylococcus aureus.* The phytochemical properties of these plants might play the major role for such antibacterial activity. Thus, these plants could be considered for finding bioactive natural products that can be a part in the development of new pharmaceuticals research activities.

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IDENTIFICATION OF MOST SUITABLE SILO FOR LIVESTOCK FARM IN EASTERN UNIVERSITY, SRI LANKA

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Abstract

Limitation of feeds in dry season is the main barrier for small scale and medium scale dairy farmers in the Eastern region of Sri Lanka. Forage conservation in the form of silage is an option to increase dry season feed availability. Therefore, this study was carried out in the Livestock Farm, faculty of Agriculture, Eastern University, Sri Lanka to identify the most suitable silo among plastic barrel silo, polybag silo, stack silo and trench silo. The four silos mentioned above were used as treatments with four replications. The experiment was conducted as Complete Randomized Design. Chopped CO3 grasses were used as silage material and silos were filled and sealed properly. Sugar was added by mixing with silage material as a silage additive. After 21 days silos were opened and samples were analyzed for silage characteristics. Physical properties such as colour, odour and texture of silage were measured by eye appraisal and sensory evaluation. Wastage, pH and proximate composition of silage were determined. Among the tested silo types, the barrel silo reported low pH value and low wastage. In barrel silo proximate composition of silage also in agreement with the standard range of proximate components. There are high pH value and high wastage of silage from polybag silo than plastic barrel silo, stack silo and trench silo.

Keywords: Silo, Forage, Dry season, CO3 grass

Introduction

In Sri Lanka Eastern region has a good potential for dairy farming due to the higher land and labor availability. Many of farmers in eastern region are small scale and medium scale farmers. Limitation of feeds in dry season is the main barrier for small and medium scale farmers to be a large scale farmer. Furthermore, feed limitation causes to low production in dry season. Forage conservation in the form of silage is an option to increase dry-season feed availability. However, in the tropics silage adoption among smallholders in general has been limited (Mannetje, 2000).

Silage making is an old agricultural practice that started more than 3,000 years ago (Wilkinson *et al*., 2003). However, a rapid increase in the application of this technology occurred after the 1940s as a result of the mechanization of forage harvesting (Wilkinson *et al*., 2003). Silage making is well established in the temperate regions of North America and Europe but has only recently become popular and widespread in tropical regions (Wilkins and Wilkinson, 2015).Important factors to

improve adoption of silage by smallholders in the tropics are low investment costs, low risks, and the potential of rapid and significant returns on investments.

The investigation was planned to identify the most suitable silo for Livestock Farm in Eastern University Sri Lanka and to evaluate the quality of silage from different silos.

Materials and Methods

The experiment was conducted during the month July, 2018 to identify most suitable silo for Livestock Farm in Eastern University, Sri Lanka. Comparisons were made with four different silos namely polythene bag silo, plastic barrel silo, stack silo and trench silo.The experiment was conducted in the Livestock farm, Department of Animal Science, Faculty of Agriculture, Eastern University, Sri Lanka. Rough roughage (CO3) was cut from the CO3 cultivation of the Livestock Farm in Eastern University, Sri Lanka just before the flowering stage and they were chopped into small pieces around 2cm using a knife. They were let to wilt slightly in breeze to reduce moisture content. Then the silage materials were mixed thoroughly to reduce variations in readings.

Four different silos were used as treatments with four replicates according to Complete Randomized Design. All silos were filled with prepared silage materials with mixing sugar. Sugar is an additive of silage that enhances the activity of lactic acid bacteria. All treatments were covered by a wooden fence and ant poison and rat poison were scattered on the surrounding floor to prevent damages on the silos by field mice, ants and other animals. After 21 days of preparation silos were opened and samples representing silage were taken from each treatment for further testing. Although there were standard methods (odor meter) available to measure physical properties (color, odor and texture), due to the time limitation for experiment those were measured by eye appraisal and sensory evaluation and the amount of deteriorate and moldy silage was measured in dry basis. pH was measured using pH meter from the extracts.

All the samples were analyzed for dry matter content, total ash content, protein content and fiber content using Proximate analysis AOAC (2000) standard method.

Final results were statistically analyzed using 'SAS 9.1.3. service pack 4, XP-PRO platform' according to Complete Randomized Design (CRD).

Results and Discussion

The physical properties of silage were given in Table 1 (colour, odour and texture).

Colour

The olive green colour was obtained in the barrel silo in the study. It was close to the original colour of the grass which was an indication of good quality silage that was well preserved (Oduguwa *et al*., 2007). In this experiment silage in barrel silo has olive

green colour and it indicates good quality of the silage. In other three silos, silage in stack silo and trench silo have brownish green colour. It indicates low quality of the silage when considering silage colour. Silage in polybag silo has dark brown – black colour. It indicates very low or poor quality. It is not suitable for animal feeding.

Odor

Normally good quality silage should have a fruity smell. Pleasantly acidic sour smell gives in quality grass silage (Kaiser *et al*., 2003). In this experiment silage prepared from barrel silo has fruity smell. It is the best odor of good quality silage. Because plastic barrel silos have less chance to enter air after proper sealing by lid. Silage prepared from polybag silo has pungent odor. The pungent odor is due to aerobic spoil on silage in polybag silos. Because polybags have a high chance to damage by ants, and physical damages and easy to enter the air into the silos. It enhances the activity of spoiling bacteria. Silage in stack silo and trench silo has a pleasant odor but not the fruity smell or sweet sour pleasant. Kaiser *et al*., (2003) reported that poor compaction and sealing results the spoilage on silage. This is the cause of moldy and pungent odor.

Table 1: Physical Properties of Silage Made from Different Silos

Parameters	**T_1**	**T_2**	**T_3**	**T_4**
Colour	Olive green	Dark brown to Black	Brownish green	Brownish green
Odor	Fruity smell	Pungent odor	Pleasant odor	Pleasant odor
Texture	Firm	Wet and mouldy	Dry and mouldy	Dry and mouldy

T_1 – Barrel silo, T_2 – Polybag silo, T_3 – Stack silo, T_4 – Trench silo

Texture

The best texture of the silage is firm texture. The texture of the silage in barrel silo was firm (Table 1) which was expected to the best texture of good silage. Slimy texture or mold or fungi growth indicates spoilage in the silage. (Kung and Shaver, 2002).

The pH value and wastage of silage were explained in Table 2. The pH value in barrel silo is significantly differing from silage made in polybag silo, stack silo, trench silo and polybag silo par with stack silo. The lowest pH value (4.25) was observed in barrel silo while trench silo recorded the highest (5.4) pH value.

Table 2. The pH and Wastage of CO3 Silage

Attributes	**T_1**	**T_2**	**T_3**	**T_4**
pH	4.25 ± 0.04^{c}	5.13 ± 0.05^{b}	5.14 ± 0.02^{b}	5.40 ± 0.05^{a}
Wastage(g) in dry basis	25.52 ± 2.99^{c}	94.90 ± 6.50^{a}	62.80 ± 4.50^{b}	54.70 ± 2.68^{b}

Means with different superscripts in the same row are significantly different ($p<0.05$).
T_1- Barrel silo, T_2- polybag silo, T_3- stack silo, T_4- trench silo

The pH value of 4.25 obtained in this study was in barrel silo agreement with 4.2 – 5.0 reported by Babayemi (2009). In other three silos pH values are higher than 5.0. It

indicates the silage in polybag silo, stack silo and trench silo have poor quality. High pH indicates poor fermentation due to dry condition of silage while low pH indicates high amount of acid production that can be detrimental to ruminants (Keady, 2011). pH is generally around 3.8-4.4 in good quality silage (Food and Agriculture Organization, 2008).

Further results showed that wastage is significantly lower in barrel silo and significantly higher in polybag silo. Stack silo is par with trench silo. Wastage is more important when selecting a good silo. Kaiser *et al*., (2003) reported that poor compaction and sealing results aerobic spoil on silage. This is the cause of high wastage.

In this study pH value in barrel silo is significantly differ from silage made in polybag silo, stack silo, trench silo and polybag silo par with stack silo. The lowest pH value (4.25) was observed in barrel silo while trench silo recorded the highest (5.4) pH value.

The proximate compositions of silage and standared ranges of proximate parameters of silage were given in Table 3 and Table 4.

Crude protein

Crude protein percentage represents total nitrogen in silage which enhances nutrition level of ruminants to their activities of maintenance, lactation, growth and reproduction (Keady, 2011). Crude protein percentages of all four treatments in this study are in agreement with the standard range according to Table 4. Among these four treatments barrel silo is significantly different from polybag silo, stack silo and trench silo. There is no significant difference between polybag silo, stack silo and trench silo. Crude protein percentage in barrel silo is significantly higher than other treatments.

Table 3: Proximate Composition of Silage in Four Different Silos:

Treatments	**Parameters**			
	DM%	**CP%**	**CF%**	**Ash%**
T_1	26.18 ± 0.15^{a}	13.30 ± 0.10^{a}	34.70 ± 0.40^{a}	14.67 ± 0.13^{b}
T_2	17.10 ± 0.15^{c}	12.50 ± 0.07^{b}	31.33 ± 0.18^{c}	16.40 ± 0.12^{a}
T_3	19.40 ± 0.16^{b}	12.43 ± 0.10^{b}	33.02 ± 0.15^{b}	14.97 ± 0.11^{b}
T_4	15.80 ± 0.09^{d}	12.35 ± 0.13^{b}	33.25 ± 0.11^{ab}	16.12 ± 0.06^{a}

Means with different superscripts in the same column are significantly different ($p<0.05$)
DM – dry matter, CP – crude protein, CF – crude fiber
T_1 – Barrel silo, T_2 – Polybag silo, T_3 – Stack silo, T_4 – Trench silo

Crude fiber

Crude fiber percentage is one of crucial parameter of silage due to high crude fiber content enhance the ability of palatability and amount of metabolic energy intake by animal while low crude fiber content indicates deterioration of silage (Keady, 2011). In this study barrel silo is significantly differ from polybag silo and stack silo. There is a lower significant difference between barrel silo and trench silo than barrel silo and

polybag silo. The highest crude fiber percentage was observed in barrel silo (34.70%) and polybag silo was recorded lower (31.33%) crude fiber level (Table 3). Due to the standard ranges (Table 4) crude fiber content of silage in barrel silo (34.70%) is in between the standard range (34-37%) and in other three treatments crude fiber content is less than the standard range.

Table 4: Standard Ranges of Proximate Parameters of CO-3 Silage

DM%	CP%	CF%	Ash%
25-35	12-15	34-37	9-12

DM – dry matter, CP – crude protein, CF – crude fiber
Senanayake *et al.* (2016).

Ash content

Ash is the parameter that indicates mineral content in silage. High ash content is observed due to poor fermentation of silage (Keady, 2011). The results of tested parameters of ash indicated that polybag silo was significantly higher (16.40%) and barrel silo was significantly lower (14.67%). But ash content in all treatments are above the standard level according to the Table 4. There is a significant difference between barrel silo and polybag silo. Barrel silo par with stack silo and polybag silo par with trench silo.

Conclusions

The study revealed that quality parameters of silage in terms of colour, odor, texture, pH and nutritional composition are better in barrel silo than polybag silo, stack silo and trench silo. Most of nutritional values and pH value of silage in barrel silo are agreement with the standard rangers of silage quality parameters. Wastage also very low in barrel silo compare with other three silos. Among these four different silos, quality of silage is poor and wastage is high in polybag silo. Because there is high chance to damage polythene bag. For stack silo and trench silo need huge amounts of silage materials to proper sealing and for low wastage. Therefore, they are not suitable for small holders.When compare the barrel silo with polybag silo, initial cost is high for barrels or any other plastic container that suitable for a silo. But its durability is very longer than polybags. Polythene bags can be used only one time as a silo due to high ability to damages. Therefore, barrel silo can be recommended for Livestock farm in Eastern University, Sri Lanka.

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SHELF LIFE EVALUATION OF SOURSOP (*Annona muricata* L.) JELLY WITHOUT PRESERVATIVES

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Abstract

Soursop fruit has a great potential to ensure food security, nutrition and generate income. Food processing industries tend to prepare various value added products using soursop fruits. Fruit jelly is a semi solid gel made from the juice, mixing with sweetening compounds. This study was focused to develop a soursop jelly and to assess its sensory qualities, physico-chemical properties and storage stability. Soursop jelly was prepared according to Sri Lankan Standard Specification for jelly by using fruit juice, sugar, pectin, citric acid and water. Assessment of physico-chemical parameters, total plate count and sensory properties was carried out after formulation and during storage. Seven points hedonic scale was used in sensory evaluation. Three formulations of 80% soursop pulp, 60% soursop pulp and 40% soursop pulp were selected based on sensory evaluation for storage studies at 28±1°C temperature and 80-90% of RH for 12 weeks. The nutritional analysis of jelly decreasing trends in pH, ascorbic acid and an increasing trend in moisture, total soluble solids, titrable acidity and total sugar was noted with advancement of storage period of 12 weeks. The sensory analysis also showed that there were significance differences ($p<0.05$) for organoleptic characters of jelly. Mean scores of all organoleptic characters were gradually decreased during 12 weeks storage period. Highest overall acceptability was observed in formulation with 80% soursop pulp and all formulations were microbiologically safe for consumption. Based on the results, the jelly with 80% soursop pulp concentration was selected as best formulation and could be stored for 12 weeks at 28±1°C temperature and 80-90% of RH without any significant changes.

Keywords: Fruit jelly, Physico-chemical parameters, Sensory evaluation, Soursop.

Introduction

Soursop is one of minor crop that is gaining popularity because of its economic uses and great demand in processing industry especially in producing of soursop drinks. The fruit is now very popular in world market therefore expansion and production should be encouraged. It is widely known to possess medicinal properties like cancer fighting, diabetes mellitus herpes inhibiting, anti-depressive, anti-bacterial and effect against *Staphylococcus aureus* and *Vibrio cholera* (Tesio, 2013). It is a nutritious fruit, it consists of 67.5% white edible pulp and it contains 80-81% water, 1% protein, 18% carbohydrate. As well as it has ascorbic acid, potassium, phosphorous and calcium and

particularly fructose, also contains significant amounts of vitamin B_1, $B_2$and vitamin B_6 (Barrette, 2013). Jelly is Fruit flavored dessert made by warming and then cooling a liquid containing setting agent in a dish it sets in semi solid someone elastic mass. It is transparent. It should be good color. Not flow, when taken from mold, with texture so tender it may be cut easily with a spoon, and yet so firm that the angles produced by cutting retain their shape.

However, it softens very rapidly following harvest, become mushy and difficult to consume as fresh fruit. So it cannot be stored for a long period of time. Therefore, it is rejected at market due to external injury, uneven shape and size.As well as soursop has sour citrus taste and no attractive external features. Through processing, the shelf life of such product can be increased. For instances juices, jam, jellies stay for a longer period. This process not only enhances the life of perishable products but also creates a good market relative to that in raw form. It helps to stabilize the prices and assists in maintaining a stock of fruits to meet the demand in off- seasons (Sinthiya and Poornima, 2017). Therefore, the research was carried out to develop a soursop jelly and to assess its sensory qualities, physico-chemical properties and storage stability.

Materials and Methods

The undamaged, healthy, mature soursop fruits were used for this study. The outer cover and seeds were removed. The flesh was cut in to small pieces and it was put in stainless steel pan and drinking water (1½ time of fruit pulp) was added in it. Then 0.2 g of citric acid was mixed and allowed to boil about 20-25 minutes. Finally boiled fruit sample was filtered through the muslin cloth and the pulp was separated. The soursop jelly was prepared by using of extracted soursop pulp and water in different ratio with certain amount of sugar, pectin and citric acid to formulate different formulations and it was boiled. Following Table 1 shows the different formulations of jelly preparation.

Table 1: Experimental Formulations for Soursop Jelly Preparation

Ingredients	T_1	T_2	T_3	T_4	T_5
Soursop pulp (%)	100	80	60	40	20
Water(%)	00	20	40	60	80
Pectin (g/100g)	1.7	1.7	1.7	1.7	1.7
Citric acid (g/100 g)	0.5	0.5	0.5	0.5	0.5
Sugar(g/100 g)	50	50	50	50	50

The soursop pulp and water were mixed in different ratio 100:00, 80:20, 60:40, 40:60 and 20:80, respectively. The formulation varying volumes of each one were lies between 100 ml to 20 ml soursop pulp and 0 ml to 80ml of water, respectively. For the preparation of soursop jelly, requisite amount of sugar 50 g was added. Then 0.5 g citric acid was added and mixture was well stirred to dissolve the sugar completely. After it was cooked by stirring continuously about 30 minutes until it was reached the end point, total soluble solid of 68^0 Brix value. Foam was removed and egg yellow

colouring 0.5ml was added. Finally it was removed from the fire and cool for 5 minutes and it was filled in to sterilized plastic cups and sealed with lids.

Based on the physico-chemical analysis, microbial assessment and sensory evaluation, three jelly formulations of 80% soursop pulp, 60% soursop pulp and 40% soursop pulp were selected for the storage studies. All the physico-chemical parameters were analyzed using the recommended AOAC (2002) methods. Moisture, pH, titratable acidity, total soluble solids, ascorbic acid and total sugar were analyzed during the storage period.

Results and Discussion

1.0 *Physico-Chemical Qualities of Soursop Jelly during Storage*

a. Moisture

The changes in moisture content during storage of soursop jelly are shown in Table 2.In all treatments, moisture content significantly ($p<0.05$) increased throughout the storage period.Maximum value of 42.43% was observed in jelly with 40% soursop pulp at the end of 12 weeks storage period. Minimum moisture content observed in Jelly with 80% soursop pulp value is 22.23%.

Table 2: Changes in Moisture Content of Soursop Jelly during Storage

Duration (Weeks)	T_2	T_3	T_4
2	22.23 ± 0.08^c	28.73 ± 0.14^b	34.15 ± 0.07^a
4	23.27 ± 0.08^c	29.33 ± 0.08^b	36.40 ± 0.17^a
6	25.37 ± 0.03^c	30.56 ± 0.12^b	38.33 ± 0.06^a
8	26.53 ± 0.08^c	32.57 ± 0.12^b	39.07 ± 0.08^c
10	30.20 ± 0.05^c	33.57 ± 0.12^b	40.27 ± 0.12^a
12	31.70 ± 0.10^c	33.33 ± 0.12^b	42.43 ± 0.12^a

Values are means of triplicates ± standard error
Values of the different superscripts in the same column are significantly different at $p<0.05$.
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

The moisture content gradually increase during storage because of it may be due to the hydrolysis of sugar into alcohol, carbon dioxide and water. Same result was reported by Rasheda (2011) guava jelly.

b. The pH

The result pertaining to the response of storage duration and different treatments of soursop jelly on pH are present in Table 03.The results indicated that the pH of soursop jelly decreased with increased duration of storage in all the formulation. There was a significant (5%) decrease in pH during storage period at ambient temperature (28 ± 1^0C). It was observed that the maximum pH (4.22) in the 40% of soursop pulp jelly formulation in 2th week and the least pH (3.18) was observed in 80% of soursop pulp in last week.

The pH of preserved products plays a role as a preservative (Akhtar *et al.*, 2010). The reason for decrease in pH might be due to the fermentation of added sugar into alcohol and carbon dioxide during the storage period.Findings of present study are accordance with the findings of Awadhesh and Bhagwan (2017) in wood apple jelly. As well as same result was reported by Rasheda (2011) in guava jelly.

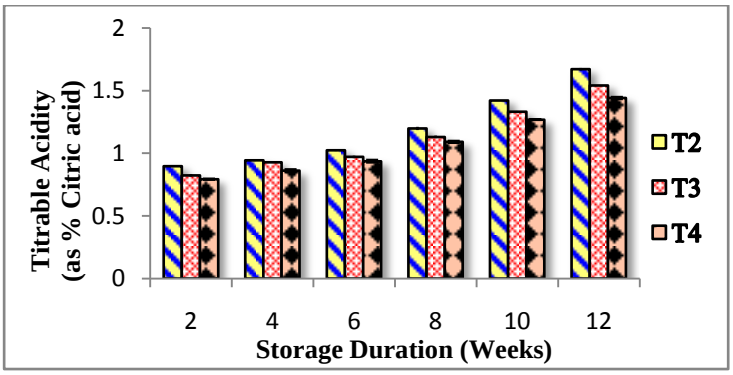
Table 3: Changes in pH of Soursop Jelly during Storage

Duration (Weeks)	T_2	T_3	T_4
2	3.67±0.005^c	4.18±0.003^b	4.22±0.005^a
4	3.56±0.012^c	4.11±0.005^b	4.19±0.006^a
6	3.46±0.002^c	4.03±0.014^b	4.14±0.005^a
8	3.35±0.008^c	3.98±0.005^b	4.08±0.000^a
10	3.29±0.005^c	3.85±0.000^b	4.00±0.006^a
12	3.18±0.003^c	3.76±0.009^b	3.88±0.003^a

Values are means of replicates ± standard error
Means with same letters in the same column are not significantly different at $p<0.05$.
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

c. Titrable Acidity

Titrable acidity changes of soursop pulp during storage are shown in Figure 1. In all treatments, titrable acidity significantly ($p<0.05$) increased through the storage period reaching maximum value of 1.67 g/100 g was observed in jelly with 80% of soursop pulp after 12 weeks. The minimum value of 0.793 g/100 g was observed in jelly with 40% of soursop pulp after two weeks. This might be due to further fermentation of alcohol produced from sugar fermentation and may be due to the addition of citric acid into the soursop jelly. Total pectic substances have been reported to increase the acidity in fruit products (Conn and Stumf, 1976), hence degradation of pectin substances of pulp into soluble solids might have contributed towards an increase in acidity of products.



Values are means of triplicates ± standard error
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

Figure 1: Changes in Titrable Acidity of Soursop Jelly during Storage

The another reason for slight increase in titrable acidity might be due to formation of organic acids by the degradation of the ascorbic acid as it decreased with storage period of the jelly. This is in consonance with the findings of Deen and Singh (2013) in karonda jelly and Kuchi *et al*., (2014) in guava jelly bar.

d. Total Soluble Solids

The changes in TSS of different formulations along with the storage are given in the Table 4.

Table 4: Changes in Total Soluble Solids of Soursop Jelly during Storage

Duration (Weeks)	T_2	T_3	T_4
2	18.23 ± 0.03^a	16.60 ± 0.05^b	9.37 ± 0.09^c
4	18.50 ± 0.00^a	16.90 ± 0.05^b	9.60 ± 0.05^c
6	18.97 ± 0.07^a	16.96 ± 0.12^b	9.70 ± 0.05^c
8	19.23 ± 0.33^a	17.10 ± 0.12^b	9.80 ± 0.05^c
10	19.40 ± 0.05^a	17.30 ± 0.20^b	10.07 ± 0.09^c
12	20.00 ± 0.05^a	17.70 ± 0.20^b	10.47 ± 0.09^c

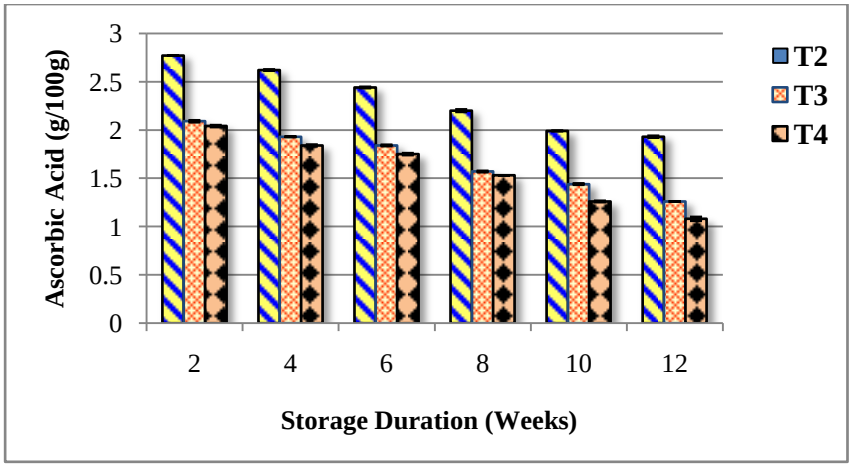
The values are means of replicates ± standard error
Values of the different superscripts in the same column are significantly different at $p<0.05$.
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

According to DMRT, there were significant differences in Total Soluble Solids among the treatments. The enhancement in the pulp content and storage period slightly increases the total soluble solids of the soursop jelly formulations which could be due to the degradation of polysaccharides into simple sugars during storage and also due to conversion of some of the insoluble fraction into soluble fraction.

Similar observations were also reported by Barmanray *et al*., (1996) in guava jelly; Chaudhary *et al*., (2007) and Jadhav *et al*., (2004) in Karonda jelly; Chopra *et al*., (2003) in wood apple jelly; Kalarani (2000) in custard apple jelly; Kotecha and Kadam (2002) in tamarind jelly and Sudhagar *et al*., (2003) in pear jelly. Maximum mean value (20^0Brix) for TSS was observed in formulation which had 80% soursop pulp in 12^{th} week of storage period. The minimum mean value of (9.37^0Brix) was observed in formulation which had 40% of soursop pulp in 2^{th} week of storage period.

e. Ascorbic Acid

The ascorbic acid content of the soursop jelly was decrease with the increase of storage period (Figure 2).The highest mean value of 2.78 g/100 g for ascorbic was observed in Jelly with 80% of soursop pulp in 2^{nd} week.



Values are means of triplicates ± standard error.
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

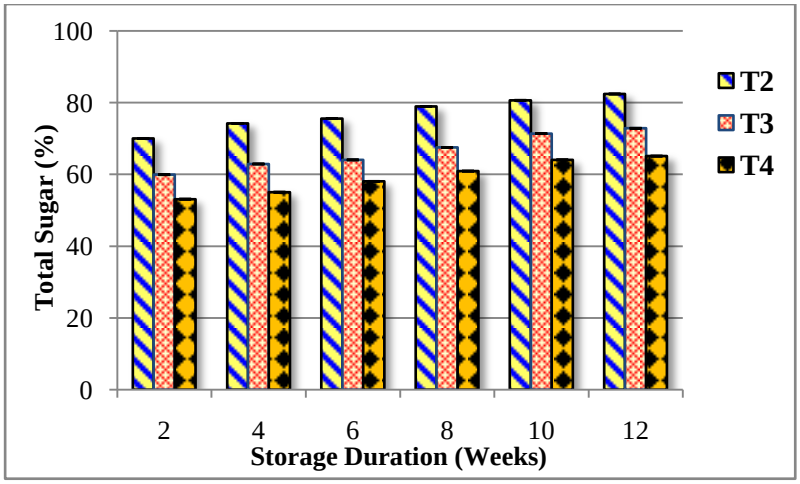
Figure 2: Changes in Ascorbic Acid Content during Storage period

The loss of ascorbic acid during storage may be due to oxidation of ascorbic acid. This oxidation due to temperature and greater catalytic activity of fructose in the catabolization of vitamin C.Similar evidences have also been reported by Jadhav *et al*., (2004) in Karonda jelly and Selvamuthukumaran (2007) in sea buckthorn jelly.

f. Total Sugar

According to Duncan's Multiple Range Test, total sugar increased significantly ($p<0.05$) throughout the storage. Total sugar in all treatments had the increasing trend with the storage period shown in (Figure 3). The highest mean value of 82.4% was recorded by Jelly formulation with 80% soursop pulp in 12th week and least mean value of 53.11% was recorded Jelly formulation with 40% soursop pulp in 2nd week.

Due to the hydrolysis of polysaccharides like pectin and starch could also be one of the reasons for increase in the sugars content. Similar observations were also recorded by the several workers like Deen and Singh (2013) in karonda jelly and Awadhesh and Bhagwan (2017) in wood apple jelly. The highest mean value (82.4%) was recorded by Jelly formulation with 80% soursop pulp in 12th week and least mean value (53.11%) was recorded Jelly formulation with 40% soursop pulp in 2nd week.



Values are means of triplicates ± standard error.
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

Figure 3: Changes in Total Sugar Content during Storage period

2.0 *Microbiological Test for Soursop Jelly*

a. Microbial Evaluation of Soursop Jelly Stored at 28±1 ºC after One Month

There was no any microbial contamination observed in the jelly samples, which were stored at ambient temperature (28 ± 1^0C). This may due to inhibition of microbial growth by sugar. Sugar interference with a microbe's enzyme activity and weakening the molecular structure of its DNA.

b. Microbial Evaluation of Soursop Jelly Stored at 28±1 ºC after Three months

There were some numbers of microbes present in the jelly sample (10^0 concentration level) of T_4 and diluted jelly samples (10^{-2}, 10^{-3} concentration level) of T_4, T_3 and T_2 at ambient temperature (28 ± 1^0C). The microbial count should not exceed to 10^3 per ml or g of jelly. The tested microbiological parameter total plate count below the reference standard.

3.0 *Sensory qualities of Soursop Jelly during Storage*

a. Colour

Colour is the first attribute considered by the consumer to judge the acceptability and overall quality of food (Al-Hooti and Sidhu, 1997). Therefore among this, colour is a one of the most important sensory quality. Attractive colour of the end product gives good demand for it. The sensory scores with respect to colour of all formulations were slightly decreased after 12 weeks of storage (Table 5). These jellies had natural colour pigments. In storage it could be attributed to enzymatic or non-enzymatic browning (Maillard reactions) In fact, the presence of a higher amount of reducing sugars after

inversion of sucrose during cooking, and/or higher pH, could contribute to these browning reactions.

Table 5: Sensory Evaluation of Soursop Jelly following 12 weeks of storage

Treatments	T_2	T_3	T_4
Colour	5.23 ± 0.02^a	5.08 ± 0.03^b	4.65 ± 0.04^c
Taste	4.27 ± 0.01^a	4.25 ± 0.04^a	4.08 ± 0.03^b
Texture	5.20 ± 0.01^a	4.56 ± 0.02^b	4.70 ± 0.03^c
Aroma	4.42 ± 0.02^a	4.26 ± 0.02^a	4.17 ± 0.12^a
Overall Acceptability	4.27 ± 0.02^a	4.25 ± 0.04^a	4.08 ± 0.03^b

The values are means of 25 replicates ± standard error
Values of the different superscripts in the same column are significantly different at $p<0.05$.
T_2 - 80% soursop pulp; T_3 - 60% soursop pulp and T_4 - 40% soursop pulp concentration.

b. Taste

The soursop jelly with 80% soursop pulp had highest score (5.2) and least mean value was observed in 60% soursop pulp. This might also be attributed to the oxidation of ascorbic acid into dehydroascorbic acid and tannins to gallic acid. Similar observations have also been reported by Chaudhary *et al*., (2007) and Jadhav *et al*., (2004) in Karonda jelly.

c. Texture

Taste gradually decreased in storage period. Decreasing of texture in all soursop jelly is shown in Table 5. The pectin content of jelly was decreased continuously which might be due to the conversion of pectin into pectic acids and further into sugars and galacturonic acids. Similar results were also observed by Barmanray *et al*., (1996) and Awadhesh and Bhagwan, (2017).

d. Aroma

Aroma plays a vital role as a sensory parameter in determining the acceptability of the new food product.According to the results obtained for aroma shown in Table 5. The mean scores for aroma revealed that there were significant reductions in aroma of soursop jelly after storage period of 12 weeks. The decrease in aroma during storage could be possibly due to loss of volatile aromatic compounds in the soursop jelly.

e. Overall Acceptability

There was a slight but significant ($p<0.05$) reduction in the overall acceptability scores of soursop jelly shown in Table 5. There was no significance difference between the treatments of T_2 and T_3. The highest mean value (4.27) in T_2 and least mean value (4.08) had in T_4. The T_2 (80% of soursop pulp) and T3 (60% of soursop pulp) were superior to others in term of overall acceptability of judges.

Conclusions

Soursop is one of the underutilized fruit in our country which is rich in various nutritious, bioactive components and antioxidant properties. However, there are limitations in exploitation of soursop because of seasonal availability, scarcity and less facility long term storage without causing alternations to their sensory qualities. Though several productive research have been done based on soursop valve addition.Formulation of soursop jelly is a new product popularizing the effective utilization of Soursop fruit and promoting the jelly production for commercial purpose from underutilized fruits. According to physico-chemical and sensory qualities of jelly with 80% of soursop pulp is the best combination for maintain the without any significant changes and extend the shelf life at 28±1°C temperature and 80-90% RH which has no any harmful effect for consumers during 12 weeks storage period.

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ASSESSMENT OF ANTIOXIDANT AND MINERAL CONTENT IN SELECTED WILD GREEN LEAFY VEGETABLES

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Abstract

Wild greens make up a significant source of antioxidants and Phyto-chemicals. In recent times natural antioxidants have gained considerable interest among nutritionists, food manufacturers, and consumers because of their safety, potential therapeutic value, and long shelf life. Minerals are inorganic substances used by the body in many ways. Three Wild Green Leafy Vegetables (WGLVs) such as *Allmania nodiflora*, *Borreria hispida* and *Rivea ornata* were selected based on the market survey. The analysis for Vitamin C, Total Phenolic Content (TPC) and Total Antioxidant Activities (TAA) was carried out using fresh WGLVs. Selected Dry WGLVs were also used to investigate some essential major elements such as Na, K, Ca and Mg by using standard methods of food analysis. The Vitamin C content was determined by 2, 4-dinitrophenyl hydrazine method (DNPH), TPC was measured using Folin-Ciocalteu reagent method and TAA was determined by the ferric reducing ability method. Among these leafy vegetables *Rivea ornata* shows higher Vitamin C, TPC and higher K, Ca and Mg content. *Allmania nodiflora* shows high TAA and Na content.

Keywords: Wild Green Leafy Vegetables, Vitamin C, Total Phenolic Content

Introduction

Plants have always been a source of inspiration and way of livelihood to human kind since time immemorial. Green leafy vegetables are rich sources of antioxidant vitamins (Gupta *et al.*, 2005). The wild edible plants growing in their natural conditions have been a source of food to the rural people inhabiting to the remote areas of the world including Sri Lanka.

Wild plants contain many natural antioxidant compounds which have been identified as a free radical or active oxygen scavengers (Zheng and Wang, 2001). Mathiventhan *et al.*, (2014) reported that 30 species of edible green leaves were obtained from home gardens, river side's and forest lands for consumption in Eastern Province of Sri Lanka.There are more wild edible leafy vegetables available in Batticaloa district, few of them are subjected to investigate Antioxidant activity and Mineral contents. Therefore, this study was aimed to investigate the presence of antioxidants and mineral content in selected WGLVs.

Materials and Methods

Sample Selection

Preliminary market survey was carried out from Kallar to Oddamavadi of the Batticaloa District, Sri Lanka in order to find out the availability of GLVs.Interviews were carried out with vegetable vendors, mainly focusing to find out the wild greens. Based on the survey three WGLVs were selected for further studies.

Identification of Wild Green Leafy Vegetables (WGLVs)

Preliminary identification of the WGLVs was done with the help of sales person in the market, personally and with the help of available sources such as herbarium specimens from the Department of Botany, Eastern University and other published documents.

Sample Collection and Treatment

Healthy, disease-free selected WGLVs were collected from local markets of three different locations in the Batticaloa district. Nine samples were collected from each leafy vegetable. Edible part of the plants were separated, washed thoroughly under running tap water and then rinsed in distilled water. They were used for the analysis of Vitamin C, TPC and TAA.Mineral analysis was also carried out using shade dried leafy vegetables.

Estimation of Vitamin C

Vitamin C was determined by using 2, 4-dinitrophenyl hydrazine methods (DNPH). This used for simultaneous determination of total vitamin C employed coupling reaction of 2, 4-dinitrophenyl hydrazine dye with vitamin C and followed by spectrometric determination (Rahman Khan *et al*., 2006). Instrument UV-Vis Spectrometer (Biobase, D580) was used. All were done in triplicates.

Estimation of Total Phenolic Content (TPC)

TPC was determined by using Folin-Ciocalteu method adapting procedures of Gupta and Prakash (2009). The results were expressed as mg Gallic acid equivalent /100 g wet weight.All were done in triplicates.

Determination of Total Antioxidant Activity (TAA)

TAA was measured using Ferric reducing antioxidant power (FRAP) assay (Benzie and Strain, 1996). The extracts were prepared using 3 different samples of each WGLVs and all analysis were carried out in triplicates. TAA was calculated using 1 mm $FeSO_4$ standard and expressed as µmol/g WW.

Mineral Analysis

Mineral content was determined by using Flame photometric and Atomic Absorption Spectrophotometric determination. Na, K, Ca were determined using Flame photometer (FP902- 5) and Mg was determined using Atomic Absorption Spectrophotometer (GBC, Sens AA, Dual).

Results and Discussion

a. Selection of Wild Green Leafy Vegetables (WGLVs)

The preliminary market survey revealed that more than 25 green leafy vegetables are available in the market throughout the year (Mathiventhan *et al*., 2014) such as *Centella asiatica, Amaranthuscoudatus, Sesbania grandiflora, Alternanthera.* At the same time, some of the GLVs are rarely available in the market such as *Allmania nodiflora, Borreria hispida, Rivea ornata, Pisonia grandis Aerva latana* during October-December, due to the seasonality.Hence it was revealed that there was a demand of such Leafy Vegetables resulting from a lower supply. By considering the consumable preference and the less availability in the market, *Allmania nodiflora*, *Borreria hispida* and *Rivea ornata were* selected for the study (Table 1, plates 1-3).

Table 1: Wild Green Leafy Vegetables collected for the study

Species Name	Family	Local Name (Tamil and Sinhala)
Allmania nodiflora	Amaranthaceae	Kumattikkirai(T), Kumatiya(S)
Borreria hispida	Rubiaceae	Nathaichoori(T), Hithhadakola(S)
Rivea ornata	Convolvulaceae	Musuttai(T)

Plate 1: ***Allmania nodiflora***

Plate 2: ***Borreria hispida***

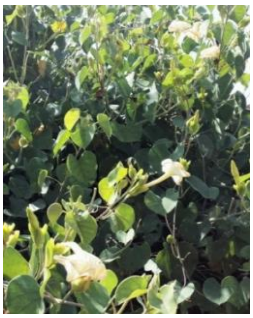

Plate 3: ***Rivea ornata***

b. Determination of Vitamin C, TPC content and TAA of studied WGLVs

In this study, the Vitamin C content of *Borreria hispida* shows lower Vitamin C content than other two studied leafy vegetables, the highest TPC was obtained in *Rivea ornata* and lowest TPC obtained in *Borreria hispida*. *Allmania nodiflora* contain higher TAA than the other selected leafy vegetables (Table 2).

Table 2: Vitamin C, TPC content and TAA of studied WGLVs.

WGLVs (mg/100g)	Vitamin C (mg GAE /100g)	TPC (µmol $FeSO_4$/g)	TAA
Allmania nodiflora	30.84±0.16	125.5±1.73	854.66±1.06
Borreria hispida	22.15±0.69	78.45±1.44	806.98±2.64
Rivea ornata	31.75±2.62	420.65±0.96	530.56±3.44

Each value represents the mean ±SD of three determinations on wet weight (WW)

Vitamin C is an essential and important nutrient for a variety of biological functions in human. In this study *Rivea ornata* showed higher vitamin C content than other leafy vegetables. The previous studies revealed that the vitamin Ccontent of leafy vegetables belong to Amaranthaceae family of *Alternanthera sessilis*, *Amaranthus viridis*, showed 36.17 and 35.58 mg/100g respectively (Umaramani and Sivakanesan, 2015), *A. tricolor, S. oleracea, A.gangeticus and C.album* showed 76.5mg/100 g, 41.2 mg/100 g, 42.2 mg/100 g and 36.0 mg/100 g respectively (Kamal *et al*., 2013) but in studied *Allmania nodiflora* belongs to Amaranthaceae family showed slightly lesser than these values and *Ipomoea batatas*, *Ipomoea aquatica Forssk* belong to Convolvulaceae family leafy vegetables showed 28.8 mg/100 g and 36.4 mg/100 g respectively (Kamal *et al*., 2013) and *Vangueria spinosus* belong to rubiaceae family showed 93.81 mg/100 g (Sakshi *et al*., 2017) butthe studied *Rivea ornata* (Convolvulaceae) showed higher vitamin C content than the above mentioned previously studied *Ipomoea batatas* and *Borreria hispida* (Rubiaceae) showed lower vitamin C content than previously studied leafy vegetables that may be due to the difference in the harvesting season and geographical location. The current recommended dietary allowance (RDA) for vitamin C content for adult men and women is 75 mg/day for women and 90mg/day for men so the considerable amount of vitamin C content of these studied leafy vegetables may also support for the daily intake of vitamin C.

Phenolic compounds belong to the category of natural antioxidants are the most abundant antioxidants in our diet. Polyphenolic compounds can also prevent the development of long-term diabetes complications, including cardiovascular disease, neuropathy, nephropathy and retinopathy (Velderrain *et al*., 2014). In the present study showed *Rivea ornata* contain high TPC than other two leafy vegetables. The phenolic and tannin content of acetone and methanol extracts of leaf, stem and flower of *A. dubius* and *A. nodiflora* were ranging from 65.47-280.47 mg GAE/g extract and 42.14-143.33 mg GAE/g extract (Dhanya *et al*., 2017). In this present study also *A. nodiflora* shows the TPC within that range. In previous study showed, TPC of *S.hispida* was 6.88±0.34 mg CAE/g and 9.17±0.46 mg TAE/g **(**Ankad *et al*., 2015). TPC of leaf, root and petiole extracts of four *C. asiatica* varieties were found to vary from 3.23 g gallic acid equivalent/ 100 g to 11.7g gallic acid equivalent/100g of dry sample (Zainol *et al*., 2003). A comparison of these values could not be made with the present study because of the difference in the standards used as well as the nature of the samples and also total polyphenolic content of vegetables varies widely depending on the variety of vegetable (Yadav *et al*., 2013). Based on this present study the TPC of studied wild leafy vegetables shows higher phenolic content than these previous studied leafy vegetables.

Antioxidants are all those elements that have the function of eliminating free radicals from our body. In a review on the AOA methods Huang *et al*., (2005) suggested that FRAP and DPPH are the two most commonly accepted assays for the estimation of AOA in plant foods. A study carried out by Siddhuraju and Becker suggested that DPPH < ABTS < FRAP showed better antioxidant and free radical-scavenging activities in processed cow pea and its seed extracts. In our study based on FRAP assay method shows higher TAA in *A.nodiflora* than other two selected leafy vegetables. The

previous studies showed that lettuce in Brazil was 447.1 µmol Fe^{2+}/g (Ana *et al*., 2012) but the studied WGLVs showed higher than this value. So based on this study the selected three WGLVs are good source for Anti-oxidants than lettuce in Brazil. And also in an earlier investigation, the levels of TAC of *A.viridis* , *A.sessilis* and *O.rubra* belongs to the family Amaranthaceae showed 3525.00 AEAC/100g, 1100.00 mg AEAC/100g and 2576.00 AEAC/100g respectively and *V.spinosus* belongs to the family rubiaceae and *I.batatas* belongs to the family Convolvulaceae showed 2584.00 and 4083.33 AEAC/100g respectively (Sakshi *et al*., 2017). In this present study, compared to *R.ornata* the total phenolic compound was low in *A.nodiflora* and *B.hispida* but these two leafy vegetables showed higher antioxidant activity than *R.ornata*. This may be due to the non-phenolic substances responsible for the anti-oxidant activity (Adriana *et al*., 2012).

c. Mineral Content of Studied WGLVs

Table 3: Mineral composition of selected leafy vegetables (mg /100g)

Minerals	*Allmania nodiflora*	*Borreria hispida*	*Rivea ornata*
Na	253.77±6.71	133.9±7.16	127.3±2.4
K	289.87±5.23	483.3±12.52	2523.3±11.53
Ca	996.67±18.3	525.53±22.54	2514.43±6.50
Mg	1513.1±10.53	1138.13±23.76	2504.17±9.97

Each value represents the mean ±SD of three determinations on dry weight (DW) basis.

Sodium content of studied leafy vegetables was remarkably similar to 246.7 mg/100g reported for the leaves of *Alternanthera sessilis* (Gotruvalli *et al*., 2016). But *Amaranthus viridis* has 108 mg/100g (Nisha *et al*., 2012). Potassium concentrations in the analyzed samples were showed lower than *Amaranthus viridis* and *Alternanthera sessilis* having value of 3460 mg/100g and 412.2 mg/100g respectively. Sodium to potassium ratio of less than one has been recommended for the prevention of high blood pressure. Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. Calcium content was found to be high in *Rivea ornata* (2514.43 mg/100g) and low in *Borreria hispida* (525.53 mg/100g). Magnesium is known to prevent cardiomyopathy, muscle degeneration, growth retardation, alopecia, dermatitis, immunologic dysfunction, gonadal atrophy, impaired spermatogenesis, congenital malformations and bleeding disorders. Based on this study *Rivea ornata* showed higher Potassium, Calcium and Magnesium content than other two WGLVs. but Sodium content is high in *Allmania nodiflora* (253.77 mg/100g) so these cheap and locally available Wild Green leafy vegetables are recommended to add in main diet as they contain considerable amount of minerals.

Conclusion and Recommendation

All three WGLVs contain Vitamin C, TPC, TAA and the Mineral Na, K, Ca and Mg. *Rivea ornata* has high Vitamin C, high TPC, high Potassium, Calcium and Magnesium content and *Allmania nodiflora* has high TAA and Sodium content. Therefore, these two WGLVs may considered as promising WGLVs. By considering the consumer

preferences and the antioxidant properties, it is advisable to domesticate these WGLVs for wider consumers and this will lead to available throughout the year.

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INFLUENCE OF SOME MATERNAL ANTHROPOMETRIC PARAMETERS ON HAEMOGLOBIN AND SERUM FERRITIN CONCENTRATION AMONG PREGNANT MOTHERS AND THE BIRTH WEIGHT OF THEIR BABIES IN THE BATTICALOA DISTRICT

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Abstract

This cross sectional study was carried out during the period from April, 2013 to March, 2015. The survey covered a representative sample size of 382 at 95% confidence level. The sampling frames for the clinics were obtained from the office of the Ministry of Health, Batticaloa. The selected subjects were informed about the study and those who were willing to participate in the study were screened by measuring their Erythrocyte Sedimentation Rate (ESR) to determine whether they were having any subclinical infections. Those who had any clinical and subclinical infections were excluded from the study. Finally, a sample size of 382 pregnant mothers aged 15 to 49 years in the second trimester was selected for this study. Pre-pregnancy height and weight, body fat percentage, birth weight of the baby, haemoglobin level, and serum ferritin level of the mothers during their second trimester were measured to assess the relationship between the anthropometric and the biochemical parameters during pregnancy. Haemoglobin level was measured by Cyanmethemoglobin method, and the serum ferritin level was measured by ELISA method. Body fat percentage was directly measured by using Warrior Digital Body Mass Caliper. Finally, data were entered and analyzed using SPSS (Version 19) and MINITAB (Version 15). Serum ferritin correlated positively with body fat percentage (r=0.771**, p=0.001) and negatively correlated with the early pregnancy BMI (r=-0.153**, p=0.003). Further, pre pregnancy BMI positively correlated with haemoglobin level (r=0.118*, p= 0.021) and their babies birth weight (r=0.22**, p=0.001) and percentage of pre pregnancy obesity decreased with increasing parity of the mothers.

Keywords: Anthropometric parameters, Birth weight, Haemoglobin, Pregnancy.

Introduction

Nutritional status, which indicates the total well-being of a population (Bhandari *et al.*, 2016) is important for good health and for increased work capacity of women, especially those who are pregnant as it affects the health of their offspring (Black *et al.*, 2008). Poor nutritional status is a greater risk to both mother and children born to them (Branca *et al.*, 2015). The intake of sufficient nutrition during pregnancy is important to the foetus to grow and develop physically and mentally to its full potential (Mann

and Truswell, 2012). Cetin *et al.* (2010) found that micronutrients have an important role to play in enzymes and transcription factors, and signal transduction pathways that regulate development, and any imbalance in micronutrients can affect pregnancy outcome. In a country like Sri Lanka where wide variations are noticeable in socioeconomic status as well as in diet, the prevalence of iron deficiency anaemia could show variations in different geographical and demographic subgroups. Since iron deficiency anaemia (IDA) is a major contributory factor for maternal morbidity as well as mortality. Due to the internal conflict over the last three decades in Sri Lanka especially in the Batticaloa region there is an absence of reliable data on nutritional status of pregnant women; especially on iron deficiency anaemia.There is lack of information regarding maternal anthropometric parametersand its association with iron status of pregnant women and their off springs in the Batticaloa district. Hence, there is a need for a rationalized data on this important health problem in this region in order to minimize this problem. Therefore, the purpose of this study was to identify the influence of some maternal anthropometric parameters on the haemoglobin and serum ferritin concentration among pregnant mothers and the birth weight of their babies in the Batticaloa District.

Materials and Methods

The study was carried out during April 2013 to March 2015 on a population based cross sectional study. The study population consisted of pregnant women attending the Ministry of Health (MOH) antenatal clinics in the selected seven Divisional Secretariat (DS) areas among 14 DS Division in the Batticaloa District. According to Cochran (1977) the sample size was calculated. In Batticaloa District, the projected 2011 population statistics showed that the number of women of child bearing age (15-49 years) was 77349 out of 162398(total female population) which is about 47.62% (Statistics hand book of Batticaloa District, 2012). The survey covered a representative sample size of 382 at 95% confidence level. The sampling frames for the clinics were obtained from the office of the Ministry of Health, Batticaloa. The selected subjects were informed about the study and those who were willing to participate in the study were screened by measuring their Erythrocyte Sedimentation Rate (ESR) to determine whether they were having any subclinical infections. Those who had any clinical and subclinical infections were excluded from the study. A detailed consent form containing the description of the study and the information about the blood collection was given to the subjects who were free from any infections and they were further explained about the nature of the study. Finally 382 apparently healthy pregnant mothers aged 15 to 49 years in the second trimester were selected.

The study was approved by the Ethical Committee of the Faculty of Health Care Science, Eastern University of Sri Lanka. Some anthropometric parameters such as pregnant mothers' weight in the second trimester of gestation (14- 26 weeks) was measured using a physician scale (Detecto, USA) with the precision of 0.1kg, height of the barefooted subjects was measured in centimetres by using a wall mounted stadiometer (Doherty, UK), pre pregnancy weight was obtained from the B card at the

first booking visit ≤ 6 weeks of gestation and it is generally agreed that the weight gain during this period is negligible (Jananthan *et al.*, 2009)., body fat percentage were measured directly by using Warrior body mass caliper (Sequoia fitness products, USA), Weights of the new born were recorded to the nearest 0.01kg within 24 hours of delivery in the labour room by senior registered nursing officer using an electronic scale. Venous blood (5ml) was collected from subjects by venipuncture. Blood collections were carried out at the antenatal clinics by the nursing officer in-charge for the clinics. Part (2ml) of collected blood was allowed to clot and then centrifuged at 3000 rpm for 5 minutes using a bench top centrifuge (Gemmy, Taiwan) to separate the serum. Finally the serum was analyzed for ferritin content by using ELISA method and the haemoglobin was determined by cyanmethemoglobin method. Processed data was analyzed using Statistical Package for Social Sciences (SPSS) and MINITAB. Descriptive statistics were used to get the percentages and frequencies of variables used in this study. Pearson's correlation analysis was performed to estimate the correlations among pre pregnancy BMI, new born's weight and the ferritin content of the mothers.

Results and Discussion

Pre pregnancy BMI of the mothers

The pre pregnancy BMI of mothers calculated based onweight at first booking visit and the mean pre pregnancy BMI of the mothers was 22.79 kg/m^2 (SD ±4.74) with a range from 13.14kg/m^2 to 40.63 kg/m^2. Of them around 40% were in the normal category, 20.4% were overweight, 21.7% were obese and 8.1% were under weight.

Table 1: Pre pregnancy BMI of mothers

	Pre pregnant BMI (kg/m^2)	
	Frequency	Percentage
Under weight(< 18.5)	69	8.1
Normal(18.5-23)	152	39.8
Over weight(23-27)	78	20.4
Obese (> 27)	83	21.7

Relationship between the pre pregnancy BMI and the body Fat percentage according to parity

According to the Chi square analysis, the table 2 shows the relationship between the pre pregnancy BMI and the fat percentage of mothers according to their parity. The result from the descriptive analysis revealed that the percentage of pre pregnancy obesity decreased with increasing parity of the mothers. The body fat percentage also reduced with increasing parity in the present study. Similar result was reported by Lassek and Gaulin (2006) in the USA.

Relationship between pre pregnancy BMI of mothers and body fat percentage in the second trimester

Pearson correlation analysis was revealed that there was a highly significant positive correlation between pre pregnancy BMI and the body fat percentage.

Table 2: Relationship between the pre pregnancy BMI and the body fat percentage of mothers according to parity

Pre pregnancy BMI(kg/m^2)	Body Fat percentage (%)		
	Low (<15%)	Normal (15-<25%)	High (>25%)
	Parity I (x^2 77.191, p =0.0001)		
Under weight(<18.5)	8.3(3)	91.7(33)	0
Normal (18.5-22.9)	0	56.7(38)	43.3(29)
Overweight(23-27)	0	4.2(1)	95.8(23)
Obese(>27)	0	0	100(15)
	Parity II (x^2 =90.851, p =0.0001)		
Under weight(<18.5)	29.4(5)	64.7(11)	5.9(1)
Normal (18.5-22.9)	0	71.1(27)	28.9(11)
Overweight(23-27)	0	4.2(1)	95.8(23)
Obese(>27)	0	2.6(1)	97.4(37)
	Parity III (x^2 = 37.92, p =0.0001)		
Under weight(<18.5)	0	83.3(10)	16.7(2)
Normal (18.5-22.9)	2.9(1)	65.7(23)	31.4(11)
Overweight(23-27)	0	13.6(3)	86.4(19)
Obese(>27)	5.9(1)	0	94.1(16)
	Parity IV (x^2 =16. 792,p = 0.002)		
Under weight(<18.5)	33.3(1)	33.3(1)	33.3(1)
Normal (18.5-22.9)	9.1(1)	63.6(7)	27.3(3)
Overweight(23-27)	0	0	100(7)
Obese(>27)	0	11.1(1)	88.9(8)
	Parity V (x^2 =4.958, p = 0.039)		
Under weight(<18.5)	0	0	0
Normal (18.5-22.9)	0	100(2)	0
Overweight(23-27)	0	50(1)	50(1)
Obese(>27)	0	100(3)	0

Values are in %, numbers of respondents are in parentheses

Association between pre pregnant BMI and the Haemoglobin concentration during second trimester

Chi-square analysis was performed to find out the association between pre pregnant BMI and the haemoglobin concentration of the pregnant mothers. There was a significant association(x^2= 4.207, p= 0.046) between pre pregnant BMI and the haemoglobin concentration of the pregnant mothers intheir second trimester. The results revealed that 41.9% of the pregnant mother with BMI in normal range had low

haemoglobin concentration and 39.5% had haemoglobin in normal range. Likewise among underweight pregnant mothers, 23.3% had low level of haemoglobin and 16.5% had haemoglobin in normal range.

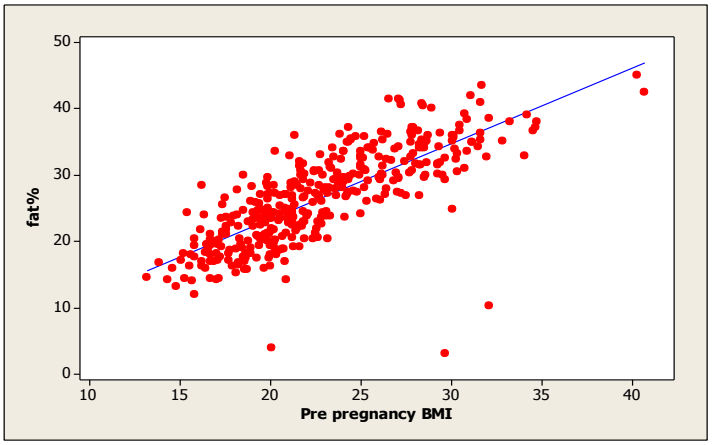

Figure 1: Relationship between pre pregnant BMI of the mothers and body fat percentage

When we consider the overweight and obese categories low percentage of mothers (19.8%, 15.1%) had low level of haemoglobin while high percentage (21%, 23%) were in the normal range. Chi square analysis showed clearly that higher pre pregnancy BMI is significantly and positively associated (x^2= 4.207, p= 0.046) with the haemoglobin level of the pregnant mothers. High pre pregnancy BMI was related to high haemoglobin levels. Under weight during pre pregnancy could be a result of under nutrition, including the fewer intakes of various micronutrients that are essential for haemato-poiesis. Similar result was reported by Mocking *et al.* (2018) in Indonesia.

Table 3: Haemoglobin concentration according to pre pregnancy BMI

Haemoglobin		Pre pregnancy BMI			
		Under weight	Normal	Over weight	Obese
Low	Frequency	20	36	17	13
	Percentage	23.3%	41.9%	19.8%	15.1%
Normal	Frequency	48	115	61	67
	Percentage	16.5%	39.5%	21.0%	23.0%

Low Hb=<11g/dl, normal = ≥ 11g/dl

Further Pearson correlation analysis was performed to assess the relationship between haemoglobin level and the pre pregnancy BMI among mothers. The results showed that, haemoglobin had a significant positive correlation (r=0.118*, p= 0.021) with pre pregnancy BMI among mothers. Likewise Bamaiyi *et al.*, (2013) found that there was a significant positive correlation between BMI at first trimester and haemoglobin

concentration among mothers in Nigeria. Zhong *et al.*, (2014) also found a significant positive correlation between BMI at first trimester and hemoglobin level, in China, indicating higher BMI will have a positive effect on haemoglobin level.

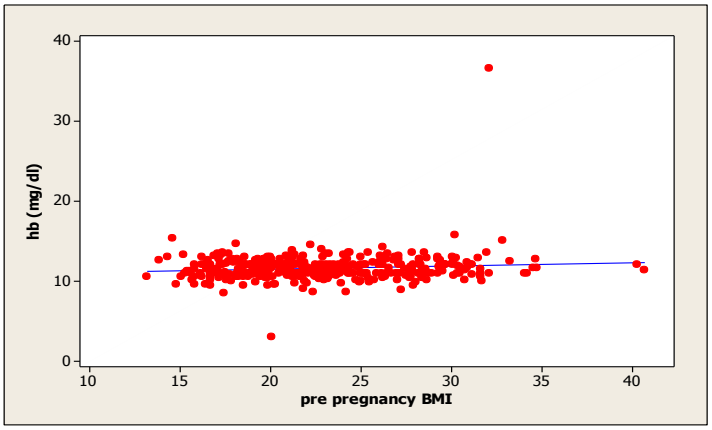

Figure 2: Relationship between the haemoglobin content during second trimester and the pre pregnancy BMI

Relationship between serum ferritin content during second trimester and the pre pregnancy BMI of mothers

Pearson correlation test was performed to assess the relationship between serum ferritin level and the pre pregnancy BMI among mothers.

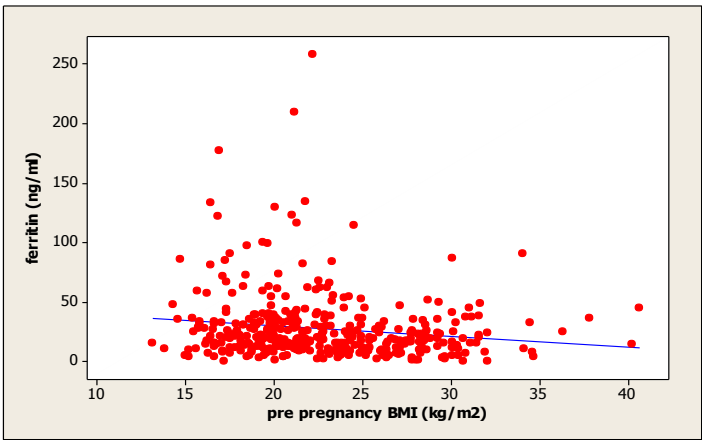

Figure 3: Relationship between the serum ferritin content and the pre pregnancy BMI

The results revealed that, the serum ferritin level had a highly significant negative correlation (r=-0.153**, p= 0.003) with pre pregnancy BMI. Similarly Garcia *et al.*, (2015) found a negative correlation between increasing BMI and the serum ferritin level among pregnant mothers in Spain. Shin *et al*, (2016) also found pre-pregnancy weight status was inversely associated with maternal iron concentrations during pregnancy.

Birth weight of the infants

The mean birth weight of the babies in the study area was 2.87 ± 0.44 kg and the percentage of low birth weight was 16%. According to the Annual Health Bulletin (2015) the overall mean birth weight of the baby was 2.88±0.47 kg, and this value is more or less same as the present study. Considering the pregnancy outcome, low birth weight among newborns is still a problem encountered in Sri Lanka, even though the percentage has gone down slightly during last three years. Studies done in developing countries suggested that the lack of knowledge about food and food fallacies are the major causes of poor maternal nutrition rather than the availability of foods. Food restrictions, avoidance of nutritional food and taboos also lead to malnutrition among pregnant mothers who delivered LBW babies (Bonnie and Rodwell, 2000).

Haemoglobin content of mothers at second trimester and birth weight of baby

Chi square analysis revealed that there was a significant positive association between the haemoglobin content of the mothers at second trimester and their newborn baby's weight (x^2 = 8.202, p= 0.032). The percentage of low birth weight babies increased through mild to severe form of anaemia inpregnant mothers. Similarly several studies also stated a strong positive relationship between maternal anaemia and low birth weight of babies (Owais Ahmad *et al*., 2011; Malhotra *et al*., 2002; Khan, 2001; Wannous and Arous, (2001). Philip (2000) reported that maternal anaemia can lead to restricted foetal growth, resulting in the infant being SGA at birth and such infants are more vulnerable to the stress of labour.

Table 4: Haemoglobin level of the participants and the birth weight of the baby

Haemoglobin level		Birth weight	
		LBW	Normal
Normal(≥ 11g/dl)	Frequency	43	250
	Percentage	14.7%	85.3%
Mild(10-1.9g/dl)	Frequency	12	54
	Percentage	18.2%	81.8%
Moderate	Frequency	6	15
(7-9.99g/dl)	Percentage	28.6%	71.4%
Severe (<7g/dl)	Frequency	1	0
	Percentage	100.0%	0%

X^2 =8.202. p= 0.032

Pre pregnancy BMI of the participants and the birth weight of the baby

According to the Chi square analysis, Table 5 shows significant (x^2=52.875, p=0.001) positive association between the earlypregnancy BMI of the pregnant mothers and the baby's birth weight.

Table 5: Pre pregnancy BMI of the participants and the birth weight of the baby

Pre pregnancy BMI	Birth weight	
	Low(<2.5kg)	Normal(≥2.5kg)
Under weight	44.9	55.1
Normal	6.6	93.4
Over weight	5.1	94.9
Obese	12	88

(x^2= 52.875, p=0.001)

Among the pregnant mothers who were underweight during their pre pregnancy, 44.9% of the mothers delivered low birth weight babies and 55.1% delivered the baby with 2.5 kg or more. Likewise among the mothers with normal BMI during pre pregnancy, only 6.6% delivered low birth weight babies. Majority (94.9%) of the pregnant mothers who were overweight during pre pregnancy delivered babies with normal birth weight. Twelve % of the mothers who were obese during their pre pregnancy delivered low birth weight babies and the overall result showed the percentage of LBW babies decreased with the increased pre pregnancy BMI of the pregnant mother. Similar result was found by Gilboa *et al*, (2008) and Bhattacharya *et al*., (2007) as they stated that pre-pregnancy underweight increased the risk of LBW.

Relationship between pre pregnant BMI of mothers and birth weight of babies

Pearson correlation analysis was performed to analyze the relationship between the pre pregnancy BMI and the birth weight of the babies; there was a highly significant positive correlation between pre pregnancy BMI and the birth weight of the babies (r= 0.220**, p= 0.001. The pre pregnancy BMI highly influenced the birth weight of the babies.

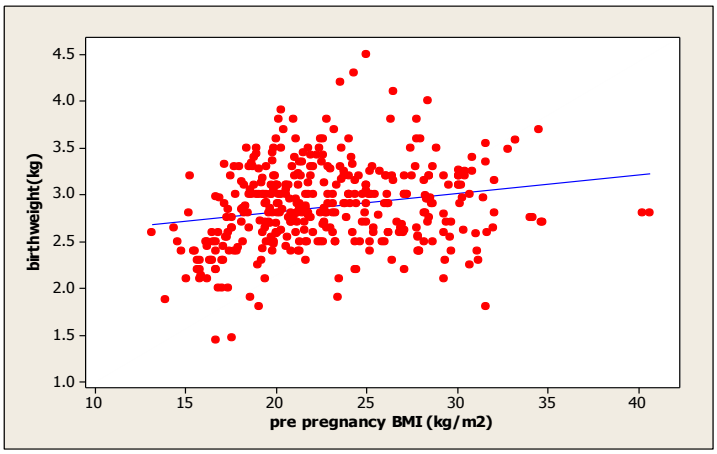

Figure 4: Relationship between pre pregnancy BMI and birth weight of the babies

Relationship between birth weight of babies and body fat percentage of mothers

Pearson correlation analysis was performed to assess the relationship between body fat percentage of the mothers and the birth weight of the babies. The results revealed that

there was a highly significant positive correlation (r= 0.167**, p= 0.001) between birth weight and the mother's body fat percentage.

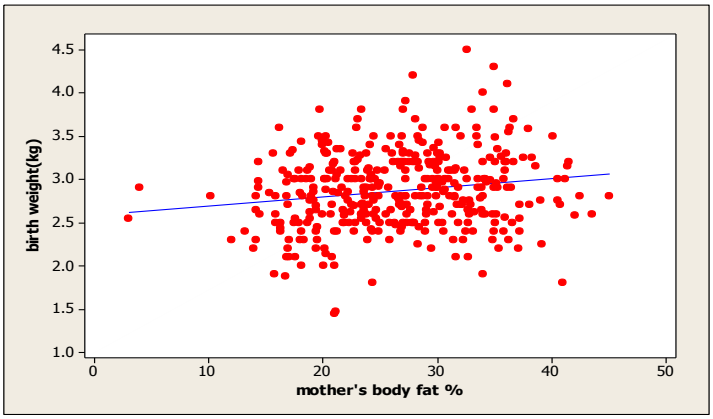

Figure 5: Relationship between mother's body fat percentage and birth weight

Conclusion

Pre pregnancy BMI of the mothers in this study positively correlated with haemoglobin level, body fat percentage and their babies' birth weight but negatively correlated with serum ferritin level. The result revealed that the percentage of pre pregnancy obesity decreased with increasing parity of the mothers. The body fat percentage also reduced with increasing parity in the present study. The birth weight of the babies in this study showed significant positive relationship with mother's body fat percentage and haemoglobin level. Serum ferritin correlated positively with body fat percentage of the mothers in this study.

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STUDY ON NURSERY MANAGEMENT TECHNIQUES FOR CHILLI (*Capsicum annum* L)

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Abstract

A field experiment was carried out at the Field Crops Research and Development Institute, Mahailluppallama (DL1b agro-ecological region) of Sri Lanka during *Maha* 2014/2015, *Yala* 2015 and *Maha* 2017/2018 seasons. The objective of the study was to identify a proper nursery technique to reduce the transplanting shock, to find out the most suitable age of transplanting and to increase the productivity by reducing the transplanting shock. The experiment was conducted both in the nursery with the objective of investigating the effect of three nursery techniques and in the field to investigate the effect of three nursery techniques and three times of transplanting on performance of chilli, respectively. As nursery techniques, normal ground nursery, parachute nursery trays, black colour plastic nursery trays and as times of transplanting, 25, 30 and 35 days old seedlings were tested. The chilli (*Capsicum annum* L) variety MICH3 was used as the test crop. Germination percentage, number of leaves at transplanting and seedling height at transplanting was highest in seedlings from the ground nursery. Field establishment percentage was lower in ground nurseries in one season while same in other two seasons. Dry chilli yield was not affected by the applied nursery techniques or age at transplanting. Production of chilli seedlings is better from well managed ground nurseries.

Keywords: Chilli, Nursery techniques, Nursery trays, Seedlings, Transplanting.

Introduction

Chilli (*Capsicum annum* L) is one of the important cash crops grown in Sri Lanka. Though the potential yield of green chilli is approximately 15 t/ha, the national average yield is only 4.74 t/ha in 2016 (DOA, 2017). Proper agronomic management practices are essential to bridge the yield gap. Chilli seeds are small and have limited food reserves. Therefore the seedlings are raised in nurseries during the early growth stages with care before transplant in the field. Nursery is the most important stage of the crop to develop a healthy and vigorous seedling that is better adapted to the harsh conditions in the field. Various nursery techniques are available for chilli mentioning ground nurseries to develop normal seedlings and nursery trays to develop plug tray seedlings. Besides normal ground nursery seedlings, plug tray seedlings have several advantages. They have little or no transplant shock leading to higher survival rate, transplanting can be done at later stages, handling is easier and can be mechanized (Jeong, 1999).

Vacant spaces in the field lead to low productivity. Pest and diseases, death of plants due to transplanting shock and inability of plants to withstand unfavorable weather conditions are some of the reasons for having vacancies in the field. Although the seedlings are uprooted carefully from moistened soil for transplanting some of the roots may be damaged. It leads to a transplanting shock and death of plants. Although the vacancies are filled by transplanting again, some vacancies remain in the field. The roots are not damaged by removing plug tray seedlings from the nursery tray. Therefore the transplanting shock can be minimized. There are several nursery trays available in the market. The parachute tray is (434 holes) used for paddy nurseries. Medium size black colour plastic tray is available (128 holes) with the dimensions of 4.5 cm height and 3 cm diameter. Planting 35 days old seedlings in the field is the general recommendation (Kannangara and Karunathilake, 2013). If the roots are not damaged during transplanting, earlier transplanting may be possible. Therefore, the objective of the study was to identify a proper nursery technique to reduce the transplanting shock, to find out the most suitable age of transplanting and to increase the productivity by reducing the transplanting shock.

Materials and Methods

The experiment was conducted in *Maha* 2014/2015,*Yala* 2015 and *Maha* 2017/2018 seasons at the research fields of the Field Crops Research and Development Institute, Mahailuppallama ($8^0$06' 42.73" N and $80^0$28' 03.27" E, Elevation 117 m above mean sea level), located in the North Central province (DL1b agro-ecological region) of Sri Lanka (Punyawardana, 2008). The soil type of the tested location is classified as Reddish Brown Earths (local) or Typic Rhodustalfs (USDA soil Taxonomy) or Rhodic Otherieutic Cutanic Luvisols (FAO classification) (Mapa *et al*., 2010).

The experiment was conducted in the nursery with the objective of investigating the effect of three nursery techniques and in the field to investigate the effect of three nursery techniques and three times of transplanting on performance of chilli. As nursery techniques, normal ground nursery, parachute nursery trays, and black colour plastic nursery trays and as times of transplanting, 25, 30 and 35 days old seedlings were tested. The chilli (*Capsicum annum* L) variety MICH3 was used as the test crop.

Seeds were sown according to the treatment structure keeping five days gap in respective nursery techniques to synchronize the date of transplanting. Top soil 1: compost 1 was taken as the nursery media. It was sterilized by burning. The nursery trays were filled with media and seeds were sown in the rate of one seed per hole in parachute trays and two seeds per hole in black colour plastic nursery trays. Normal ground nursery was prepared and sterilized by burning before seeding. Row seeding was done. All the nurseries were mulched using paddy straw and treated with a fungicide solution. Straw mulch was removed at the time of germination and nursery was maintained as recommended by the Department of Agriculture. Land preparation, fertilizer application, and organic matter applications were done as recommended by the Department of Agriculture. Plots were 14.6 m^2 in size. Seedlings were planted in

plots at a spacing of 60 x 45 cm according to the treatments structure. Treatments were laid out in a Randomized Complete Block Design with three replicates. Dry chilli yield was taken as the data from the field experiment. Analysis of Variance (ANOVA) was carried out using the Statistical Analysis System (SAS institute Inc.). Mean separation was performed using Duncans' Multiple Range Test.

Results and Discussion

Germination percentage was highest in ground nurseries in all the seasons while it was lowest in parachute trays (Table 1). The small amount of potting mixture and small size of the hole in parachute trays may lead to low germination percentage due to easy drying (Longman, 1999).

Table 1: Germination percentage (%) in parachute trays, black colour plastic trays and ground nursery during *Maha* 2014/2015, *Yala* 2015 and *Maha* 2017/2018

Treatment	*Maha* 2014/2015	*Yala* 2015	*Maha* 2017/2018
Nursery type			
Parachute trays	40.2[c]	47.4[b]	45.8[b]
Black colour plastic trays	49.7[b]	51.4[b]	78.9[a]
Ground nursery	56.5[a]	61.8[a]	78.1[a]
CV %	17.9	16	17.8

Values in each column followed by the same letters are not significantly different at 0.05 probability level

Field establishment percentage was lower in seedlings from ground nursery in one season. But it was not significantly different in other two seasons (Table 2).

Table 2: Field establishment percentage (%) of seedlings from three nursery techniques (parachute trays, black colour plastic trays and ground nursery) and three ages at transplanting (25, 30 and 35 days)

Treatment	*Maha* 2014/2015	*Yala* 2015	*Maha* 2017/2018
Nursery type			
Parachute trays	96.2[a]	97.9	96.9
Black colour plastic trays	97.1[a]	98.6	96.9
Ground nursery	92.5[b]	93.7	95.0
Age at transplanting			
25 days	93.1	98.0	95.7
30 days	97.1	96.4	96.2
35 days	95.5	95.9	97.3
CV %	3.5	6.1	3.6

Values in each column followed by the same letters are not significantly different at 0.05 probability level

Establishment percentage was not significantly affected by age at transplanting. If sufficient amount of moisture is available and avoid transplanting during hot sunny hours field survival percentage can be increased even in 25 and 30 days old seedlings. Although literature provides the evidence of increased field establishment with plug tray seedlings (Javanmardi and Moradiani, 2017), it was not significantly different in the present study. Although the plug tray seedlings had a plug of undamaged roots and growing medium, seedlings from the ground nursery also could establish well in the field. This could be done by careful removal of seedlings from moistened ground nursery, transplanting in late afternoon by avoiding hot sunny hours and supply of water for better field establishment.

Seedling height at transplanting was highest in seedlings from the ground nursery in all the seasons at three ages (Table 3). According to Anon (2018) tray seedlings showed better plant growth performances which are not comparable with the present study. Since the seeds were not sown densely and row seeding was practiced in the ground nursery, there was enough space to for vigorous seedling growth in the present study.

Table 3: Seedling height (cm) at transplanting in seedlings from three nursery techniques (parachute trays, black colour plastic trays and ground nursery) and three ages at transplanting (25, 30 and 35 days)

Nursery type	Age at transplanting								
	25 days			30 days			35 days		
	Maha 14/15	*Yala* 2015	*Maha* 17/18	*Maha* 14/15	*Yala* 2015	*Maha* 17/18	*Maha* 14/15	*Yala* 2015	*Maha* 17/18
Parachute trays	4.5[b]	6.7[b]	7.1[b]	5.4[b]	7.4[b]	7.9[b]	6.3[c]	8.6[b]	9.1[b]
Black colour plastic trays	3.9[c]	6.3[b]	6.6[b]	5.7[b]	7.5[b]	7.8[b]	7.4[b]	9.2[b]	9.5[b]
Ground nursery	8.5[a]	7.7[a]	11.0[a]	9.4[a]	8.1[a]	13.2[a]	10.1[a]	14.3[a]	24.0[a]
CV %	7.3	15.7	6.2	10.3	9.4	7.3	13.9	15.3	10.5

Values in each column followed by the same letters are not significantly different at 0.05 probability level

Number of leaves was highest in seedlings from the ground nursery (Table 4). As mentioned in the discussion of plant height, the seedlings in ground nursery were able to develop vigorously with available space and depth in the nursery bed. Number of leaves in the parachute trays was always lower at 35 days of age.

Table 4: Number of leaves at transplanting in seedlings from three nursery techniques (parachute trays, black colour plastic trays and ground nursery) and three ages at transplanting (25, 30 and 35 days)

Nursery type	Age at transplanting					
	25 days		30 days		35 days	
	Maha 14/15	*Maha* 17/18	*Maha* 14/15	*Maha* 17/18	*Maha* 14/15	*Maha* 17/18
Parachute trays	5^{b}	5^{b}	6^{b}	6^{b}	7^{c}	6^{c}
Black colour plastic trays	5^{b}	6^{b}	6^{b}	6^{b}	7^{b}	7^{b}
Ground nursery	8^{a}	7^{a}	8^{a}	8^{a}	8^{a}	9^{a}
CV %	3.7	9.5	7.7	8.6	8.5	6.2

Values in each column followed by the same letters are not significantly different at 0.05 probability level

Small cell size in parachute trays may lead to slower plant growth at the age. Further, small volume of nursery medium in the cells of parachute trays may act as a limited factor which leads to slower plant growth. Dry chilli yield was not influenced by the nursery type or age at transplanting (Table 5).

Since there was no significant effect of field establishment percentage all the treatments had similar plant population. Therefore, the yield also not affected by different nursery techniques or age at transplanting. Although the nursery technique and age at transplanting were different, the plants were able to withstand harsh conditions in the field and produce similar yields. The number of leaves at transplanting in all the treatments were five or above five. However, seedlings with at least five leaves are recommended for transplanting (Kannangara and Karunathilake, 2013).

Careful management, proper application of fertilizer and better care for pests and diseases problem will lead to good plant stand, optimum growth of the plants and ultimately good yield. A study done with strawberry transplants as plugs with different cell sizes and bare root transplants revealed that total yield did not influenced by the treatments (Gimenez *et al*., 2009).

Table 5: Dry chilli yield (t/ha) from plants transplanted from three nursery techniques (parachute trays, black colour plastic trays and ground nursery) and three ages at transplanting (25, 30 and 35 days)

Treatment	*Maha* 2014/2015	*Yala* 2015	*Maha* 2017/2018
Nursery type			
Parachute trays	1.68	3.04	0.75
Black colour plastic trays	1.94	3.44	0.94
Ground nursery	1.89	3.31	1.07
Age at transplanting			
25 days	2.16	3.04	0.83
30 days	1.62	3.34	0.89
35 days	1.76	3.41	0.99
CV %	14.6	12.5	28.2

Values in each columns are not significantly different at 0.05 probability level

Conclusions

The germination percentage, number of leaves at transplanting and seedling height at transplanting was highest in seedlings from the ground nursery. The dry chilli yield was not influenced by the nursery technique or age at transplanting. Therefore production of chilli seedlings is better from well managed ground nurseries. It is suggested that to study the effect on seedling performance by improving the media of the seedling trays.

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MARKETABLE POD YIELD OF OKRA (*Abelmoschus esculentus*) CV. HARITHA AS AFFECTED BY THE FOLIAR APPLICATION OF MORINGA (*Moringa oleifera*) LEAF EXTRACT

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Abstract

The modern intensification of agricultural practices has an impact on degradation of soil fertility, balance of the eco-system and eventually on crop yields. In fact, usage of organic and low-cost technologies to enhance the crop yield is most favorable to environment as well as human. In this regard, a field experiment was conducted at the Crop Farm, Eastern University, Sri Lanka to find out the effects of Moringa Leaf Extract (MLE) as foliar application on marketable pod yield of okra cv. Haritha. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. The treatments were; T_0 - control (Distilled water),T_1 - 10% MLE at once a week interval, T_2 - 10% MLE at once in two weeks interval, T_3 - 20% MLE at once a week interval, T_4 - 20% MLE at once in two weeks interval, T_5 - 30% MLE at once a week interval and T_6 - 30% MLE at once in two weeks interval. Foliar application of MLE was started at two weeks after germination to pod formation and each plant was sprayed with 25 ml of MLE. All agronomic practices were carried out in accordance with the department of agriculture recommendation. Foliar application of MLE with 10% concentration at one week interval had significant ($p<0.05$) effects on tested parameters compared to control. Foliar application of MLE with 10% concentration at one week interval increased the length of pod, girth of pod, number of seeds/pod, number of pods/plant and fresh weight of pods/plant. Therefore, it is concluded that the foliar application of MLE at 10% concentration level at one week interval can be used to enhance the marketable pod yield of okra cv. Haritha.

Keywords: Foliar application, Moringa Leaf Extract (MLE), Okra, Organic, Yield.

Introduction

Tropical soils are mostly affected by erosion, result in depletion of the soil nutrients and population of soil organism. Hence, preserving the soil nutrient is one of the major problems in tropical agriculture. However, due to the above reasons, the crop yield reduces gradually while challenging the fulfillment of the demand of the growing population. Inorganic fertilizers can be applied to improve yield, but they are deleterious to the environment and human health and increase the cost of production. Therefore, there is a need to find out a mechanism that provides high yield by low cost. Recently, there has been a growing trend of applying Moringa (*Moringa oleifera*) Leaf Extract (MLE) as a foliar application which is one of the cheap and environmentally

friendly organic techniques to increase the crop growth and yield. The MLE has zeatin and cytokinin which may enhance growth performances and increases crop yield (Culver *et al*., 2012).

In Sri Lanka, okra (*Abelmoschus esculentus*) is cultivated as a commercial vegetable crop, ranked fourth in cultivated extend among the low country vegetables (Anon., 2007). Okra is a nutritious vegetable which can prevent the malnutrition due to its high nutritive value such as proteins, fat, carbohydrate, minerals, vitamins and essential amino acids (Singh *et al.*, 2014). However, the okra yield is low especially, in Batticaloa district. Therefore, the objective of the present study was to investigate the effect of different concentrations and frequencies of application of MLE as a foliar application on marketable pod yield of okra cv. Haritha.

Materials and Methods

The study was carried out at the Crop Farm of Eastern University, Sri Lanka (latitude 7^0 43$^{'}$ and longitude 81^0 42$^{'}$) during June to September 2018 by employing Randomized Complete Block Design with three replications. Soil texture was sandy regosol and the presoaked seeds were sown with 60 cm × 60 cm spaced. Nitrogen, phosphorous and potassium fertilizers were applied at 150 kg ha^{-1}, 200 kg ha^{-1} and 75 kg ha^{-1} respectively as basal application.

Collection of Moringa leaves

The young Moringa leaves were collected along with tender parts of Moringa, picked with hands and they were kept in polythene bag immediately after harvest and transported to the Crop Science Laboratory, Eastern University, Sri Lanka. After that, they were cleaned with tap water and lastly with distilled water and allowed to dry under shade for a period of four days. Then, they were ground to form coarse powder using laboratory blender and then they were dissolved in distilled water at a ratio of 1:20 (w/v). Then it was autoclaved (121°C, 15 lbs sq^{-1} inch for 20 minutes) and the hot extract was filtered through double layered cheese cloth and it was allowed to cool at 4°C. 100% MLE was prepared after centrifuged (5000 × g for 15 minutes) the extract and collecting the supernatant (Yasmeen, 2011). The different concentrations of MLE such as 10%, 20% and 30% were prepared by adding distilled water at volume basis.

Physio-Chemical Analysis of Moringa Leaf Extract (MLE)

The MLE was analyzed for different nutrients at the analytical laboratory of CIC, Pelwehera (October, 2008).MLE was sprayed at the rate of 25 ml per plant in each concentration (10%, 20% and 30%) at one week and two weeks interval starting from two weeks after germination to pod formation while distilled water was applied to the control treatment.

Data Collection and Analysis

The yield parameters were collected in the experiment at 6 and 7 weeks after planting (WAP). Data were subjected to Analysis of Variance using SAS and treatment means were separated by Duncan Multiple Range Test at 5% significance.

Variables	Unit	Value
Colour	-	Pale brown
pH	-	4.20
EC	uS/cm	5380
Nitrogen	%	0.07
Phosphorous	ppm	131
Potassium	ppm	862
Calcium	ppm	112
Magnesium	ppm	194
Copper	ppm	1.5
Iron	ppm	2.9
Manganese	ppm	1.7
Zinc	ppm	1.3

Results and Discussion

Length of pods

The length of okra pods was significantly influenced ($p<0.05$) by the application of MLE (Table 1).Application of MLE at the rate of 10% increased 23.8% length of pods than control. Therefore, T1 (10% MLE at one week interval) was the best among the treatments tested. This might be due to high the number of leaves hence increase net assimilations in the plant, ultimately the length of pods (Thomas and Howarth, 2000).

Table 1: Effects of different concentrations of Moringa Leaf Extract (MLE) on length of pods at different stages of crop

Treatment	Weeks After Planting (WAP)	
	6	7
T0	$1.35^{b} \pm 0.67$	$8.71^{e} \pm 0.20$
T1	$4.63^{a} \pm 0.40$	$15.35^{a} \pm 0.30$
T2	$2.49^{ab} \pm 0.22$	$9.97^{d} \pm 0.02$
T3	$2.83^{ab} \pm 1.41$	$12.94^{b} \pm 0.05$
T4	$3.57^{ab} \pm 0.74$	$11.41^{c} \pm 0.11$
T5	$2.76^{ab} \pm 0.69$	$9.67^{d} \pm 0.15$
T6	$1.94^{ab} \pm 0.97$	$8.86^{e} \pm 0.13$
P Value	< .0001	< .0001

** p< 0.05- NS; Not Significant*

Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT).

Value represents mean ± standard error of three replicates.

Girth of pods

The data presented in Table 2 clearly showed that the MLE played a significant role in average girth of pods. At 6 WAP, the maximum girth of the pod was in T1 and it was significantly higher ($p<0.05$) than the control treatment (Table 2). At 7 WAP (At harvest), the maximum girth of pods was observed in T1 followed by T3 and T4 while the minimum girth of pods was observed in control treatment (T0) (Table 2).

Table 2: Effects of different concentrations of Moringa Leaf Extract (MLE) on pod girth at different stages of crop.

Treatment	Weeks After Planting (WAP)	
	6	7
T0	$1.07^{b} \pm 0.53$	$3.70^{e} \pm 0.09$
T1	$3.86^{a} \pm 0.35$	$5.87^{a} \pm 0.32$
T2	$2.12^{ab} \pm 0.18$	$4.26^{bc} \pm 0.02$
T3	$2.32^{ab} \pm 1.15$	$4.37^{b} \pm 0.11$
T4	$2.91^{ab} \pm 0.58$	$4.35^{b} \pm 0.04$
T5	$2.31^{ab} \pm 0.56$	$4.15^{bc} \pm 0.02$
T6	$1.56^{ab} \pm 0.78$	$3.84^{cd} \pm 0.03$
P Value	< .0001	< .0001

** p< 0.05- NS; Not Significant*
Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT).
Value represents mean ± standard error of three replicates.

According to these results, application of MLE as a foliar spray increased the girth of pods by 2% compared to control treatment.Therefore, foliar application of MLE at the rate of 10% at one week interval was best. This might be due to the availability of iron (Fe) and gibberellins in MLE. Gibberellin is responsible for the cell division and cell enlargement and iron had a role in the mobilization of food material. Thomas and Howarth (2000) reported that MLE caused greater assimilates from the leaves and that had been translocated to the pods. Anyaegbu (2015) reported that application of MLE at the rate of 100 g/8 L water at 2 weeks interval increased the girth of okra pod compared with other leaf extracts tested.

Number of seeds/pod

Table 3: Effect of different concentrations of Moringa Leaf Extract (MLE) on number of seeds/pod at 7 WAP (at harvest)

Treatment	7 WAP
T0	$24.3^{c} \pm 0.66$
T1	$42.0^{a} \pm 0.00$
T2	$38.7^{b} \pm 0.33$
T3	$40.0^{b} \pm 0.58$
T4	$39.7^{b} \pm 0.33$
T5	$39.3^{b} \pm 0.66$
T6	$39.0^{b} \pm 0.58$
P Value	< .0001

** p< 0.05- NS; Not Significant*

The number of okra seeds was significantly influenced ($p<0.05$) with the application of MLE. At 7 WAP (At harvest), the highest number of seeds was observed in T1 while the lowest number of seeds was observed in the control treatment (Table 3).

The treatment T2 was on par with T3, T4, T5 and T6 (Table 3). Therefore, application of MLE significantly influenced ($p<0.05$) the number of seeds/pod (by 1.7%). This result is in agreement with Phiri (2010) who reported that more grain formation due to growth hormones and micronutrients present in MLE. Afzal *et al*. (2015) reported that the number of grains per spike of wheat was increased with 2% MLE. However, in this study, the concentration was five (5) times greater than Afzal *et al*. (2015).

Hundred (100) Seed weight

Effect of different concentrations of MLE on 100- seed weight is given in Table 04. There was no significant difference among the treatments tested. Foliar application of MLE not significantly ($p<0.005$) affect the 100 seed weight of okra. In contrast, Zaky and Rady (2015) reported that the application of MLE (1:30) at 25 and 40 days after sowing as both seed soaking and foliar application, increased the seed weight/plant of common bean compared to control treatment. Similar results have been reported.

Table 4: Effects of different concentrations of Moringa Leaf Extract (MLE) on 100 seed weight of okra

Treatment	100 seed weight (g)
T0	6.55 ± 0.26
T1	6.28± 0.08
T2	5.58± 1.12
T3	5.71 ± 0.31
T4	5.35 ± 0.61
T5	5.63 ± 0.36
T6	5.66 ± 0.20
P Value	NS

** p< 0.05- NS; Not Significant*
Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT).
Value represents mean ± standard error of three replicates. NS means no significant difference.

Number of pods

Exogenous application of MLE significantly influenced ($p<0.05$) the number of pods/plant. Although, at 4 WAP, no significant difference was observed among the treatments tested (Table 5). At 7 WAP, the maximum number of pods/plant was observed in T1 followed by T3 and the minimum number of pods/plant was observed in T0 (Table 5). This is in accordance with Bashir *et al*. (2014) who reported that MLE increased the number of pods/plant (by 2.85%). MLE at 10% concentration at one week interval was best in this investigation. This might be due to the presence of indol acetic acid (IAA) and gibberellins (GA_3) in MLE increased the number of pods. These results were parallel to those of Khandaker *et al*. (2018) who reported that IAA and GA_3 increased the number of okra pods. The micronutrients that are enriched in MLE also influenced to fruit set. Zinc improves the number of fruits and this might be due to

the involvement of zinc in photosynthesis, activation of enzyme systems, protein synthesis and carbohydrate translocation. The results of this investigation are in agreement with the findings of Ogbuehi and Agbim (2018) who reported that the application of 10% MLE increased the number of pods of soybean. Similar results have been reported with *Solanum melongena* (2 kg Moringa leaves/20 L water) (Ozobia, 2014) and in pepper (4% MLE) (Hala and Nabila, 2017).

Table 5: Effects of different concentrations of Moringa Leaf Extract (MLE) on number of pods/plant at different stages of crop

	Weeks After Planting (WAP)	
Treatment	6	7
T0	0.7 ± 0.33	2.7^{e} ± 0.33
T1	2.3 ± 0.33	7.7^{a} ± 0.33
T2	1.0 ± 0.00	5.0^{c} ± 0.00
T3	2.0 ± 0.99	6.3^{b} ± 0.33
T4	1.7 ± 0.33	5.3^{c} ± 0.33
T5	1.3 ± 0.33	4.0^{d} ± 0.00
T6	1.3 ± 0.58	3.3^{de} ± 0.33
P Value	NS	< .0001

** p< 0.05- NS; Not Significant*
Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT).
Value represents mean ± standard error of three replicates. NS means no significant difference.

Yield of pods

Application of MLE significantly influenced ($p<0.05$) fresh weight of pods/ha and the highest fresh weight of pods was recorded in T1 (7.39 ton/ha) followed by T3 (4.52 ton/ha). Treatment T2 was on par with T5, T6 and T0 (Table 6).

Table 6: Effects of different concentrations of Moringa Leaf Extract (MLE) on marketable yield/ha of okra

Treatment	Total yield (ton/ha)
T0	2.21^{d} ± 0.24
T1	7.39^{a} ± 0.44
T2	2.73^{cd} ± 0.13
T3	4.52^{b} ± 0.34
T4	3.57^{c} ± 0.10
T5	2.87^{cd} ± 0.27
T6	2.56^{d} ± 0.23
P Value	< .0001

** p< 0.05- NS; Not Significant*
Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT).
Value represents mean ± standard error of three replicates. NS means no significant difference

Jason (2013) and Fuglie (2008) documented that MLE increased yields by 25-30% for nearly any crop due to the presence of Zeatin, a plant growth hormone. In this study, yield increased by three-fold compared to control. This might be due to increased chlorophyll contents by the application of MLE which in turn led to greater production of yield in crops because higher chlorophyll resulted in greater photosynthesis.

MLE makes the best use of photosynthesis and increasing sink capacity through supply the photo-assimilates from leaves and translocation to produce higher yield and also zeatin, a cytokinin maintain the green photosynthetic area by delaying senescence and affecting source-sink strength to increase yield. This result is in agreement with the findings of increased yield in orange (3% MLE) (Abo El-Enien *et al*., 2015) and in grape (2% MLE) (Bassiony and Ibrahim, 2016).

Conclusions

Application of MLE significantly improves the length of pod, the girth of the pod, number of seeds/pod, number of pods/plant and fresh weight of pods/plant of okra. It is concluded that application of MLE can be used to improve the marketable pod yield of okra.

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SCREENING OF MUNGBEAN (*Vigna radiata*) ACCESSIONS UNDER INTERMITTENT DROUGHT STRESS

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Abstract

Drought or low soil moisture is a one of the key problem of achieving potential yield from munbean (*vigna radiata*). This study was planned to assess and screen suitable mungbean germplasam for drought survival using morphological and physiological traits. Trial was conducted at the Field Crops Research and Development Institute, *Mahailluppallama*, Sri Lanka during season of 2015/16. The experiment was laid out as two factor factorial in randomized complete block design with two replicates. Thirty-four mungbean lines were evaluated against three irrigation regimes. Multiple variance analysis and principal component analysis were used to screen best mungbean genotypes. Tolerance index of tested genotypes were shown 10 potential elite genotypes including MI5. Principal components were determined firstly by canopy diameter, leaf area and leaf dry weight, secondly by shoot and root length indicating possibilities of using such characters for screening. Bi-plots showed different clustering in two irrigation regimes, though sound performing nine mungbean genotypes were recognized as potential candidates for drought endurance.

Keywords; Drought, Genotypes, Irrigation regimes, Mungbean, Screen

Introduction

Mungbean (*Vigna radiata*) is an important, self-pollinated diploid legume crop and environment friendly food grain legume of dry land agriculture with rich source of nutrients. Fast growth, nitrogen fixation ability, soil reinforcement and prevention of soil erosion are some other advantages of mungbean (Ranawake *et al*., 2011). Mungbean is a common crop in low-land paddy as a relay or inter-seasonal crop, in uplands as a major crop in *Yala* and also appeared in many other minor cropping systems in Sri Lanka (Sangakkara *et al* 2000 and Costa *et al* ,1999). Yield response of mungbean to irrigation at various phenological stages in terms of radiation interception, radiation-use efficiency and harvest index differs (Costa *et al*., 1999). Yield of mungbean is more dependent on adequate supply of water than on any other single environmental factor (Kramer and Boyer, 1997).

Mungbean in dry zone is often influenced by intermittent drought or different degrees of low moisture stresses is the major constrain for achieving optimum growth and

effective pod filling (Ranawake *et al*., 2011). Despite mungbean has been recognized as a drought enduring crop, inconsistency in yields depending on the degree of moisture stress is evident (De Costa *et al.*, 1999) Low moisture had significant impact on plant height, number of leaves, number of floral buds, dry matter weight of shoot system, number of lateral roots, length of tap root, number of root nodules and dry matter weight of root system (Ranawake *et al*., 2011).

Out of many solutions, a drought enduring variety or a plant type is a much feasible solution. The path of producing such variety can be started by screening the current germplasms for drought enduing characters and associating such with high yielding plant types by breeding. Therefore, this study was designed to screen out possible candidate plant types for drought endurance using some easily accessible plant characters.

Materials and Methods

The study was conducted at Field Crops Research and Development Institute (FCRDI), Mahailluppallama, Sri Lanka which is located in North Central Province of Sri Lanka, (8° 07' 00'' N, 80° 28' 00'' E) during season of 2015/2016. Location belongs to DL 1b agro ecological region (Punyawardena *et al.*, 2003), where the altitude is 117.25m above from mean sea level. The average rainfall is less than 1140mm and the mean temperature is 25.5°C during *Maha* season. Soil type is Reddish Brown Earth (RBE) characteristically with high gravel content (Mapa *et al*., 2005). The experiment was conducted in a movable rainout shelter and one treatment was conducted outside the rainout shelter.

Experiment was laid out in a Randomized Complete Block Design (RCBD) with two factor factorial experiment. Main factor was Irrigation regime based on the allowable depletion level (ADL) and sub factor was genotype. In two replicates, each containing three (3) allowable depletion level and thirty-four (34) genotypes were maintained respectively. Three irrigation regimes were used defined as ADL of 50-55, 65-70 and above 80% with the irrigation interval of 7-8, 14-16 and 21-24 days, respectively. 34 mungbean genotypes were named as MI6, MI5, MIMB1016, MIMB918, MIMB908, MIMB1000, MIMB945, MIMB1022, MIMB937, MIMB923, MIMB924, MIMB1019, MIMB936, MIMB922, MIMB950, MIMB952, MIMB949, MIMB948, MIMB938, MIMB940, MIMB939, MIMB953, MIMB971, MIMB976, MIMB901, MIMB1005, Ari, MIMB902, MIMB986, MIMB914, MIMB921, MIMB911, MIMB907 and MIMB910. Drip irrigation was used for irrigation scheduling. Sixteen (16) plants were maintained for each treatment combination in 10 x 15 cm spacing. Fertilizer was applied as recommended by the Department of Agriculture.At each treatment level, all measurements were collected prior to apply respective irrigation treatment. Destructive plant sampling was done to measure total dry matter accumulation of each genotype in each treatment. SPAD reading, IR reading, morphological parameters named as canopy diameter, plant height, number of branches, root and shoot length and leaf area and yield parameters named as number of pods per plant, no of seeds per plant and seed

weight were measured. SPAD-502 plus Chlorophyll meter, LI-3100C leaf area meter were used respectively to measure chlorophyll content and leaf area. Soil samples were collected just before the irrigation and oven dried soil samples were measured to calculate gravimetric soil moisture content (Shukla *et al.,* 2014).Interaction between genotypes and irrigation regimes was derived for measured parameters using an analysis of variance and Tukey's procedures. A principle component analysis was executed for constructing variables that account greater variability. Scores by each variable were used to screen the best performing genotypes at each stress level.Tolerance index was calculated using a modified equation by Dutta *et al.,* (2008).

$$\text{Tolerance Index} = \frac{\text{Dry weight of plant in stress (g)}}{\text{Dry weight of plant in control (g)}}$$

Results and Discussion

Meteorological conditions

Rainfall and pan evaporation were measured to calculate the water balance of the rain fed conditions and in order to visualise the severity of stress at outside environment. During the study period, cumulative rainfall was 441.8 mm and cumulative pan evaporation was 158.5 mm, with a net water deficit/balance of 283.3mm. (Figure 1) Except few days, daily rainfall was greater than daily pan evaporation. A brief period of negative water balance was observed from 12 to 16 DAS, 36 to 43 DAS, and 55 to 61 DAS. These periods were coinciding with vegetative growth, at flower initiation and seed filling respectively. Nevertheless, rain fed treatment had sufficient moisture for plant growth through the crop duration.

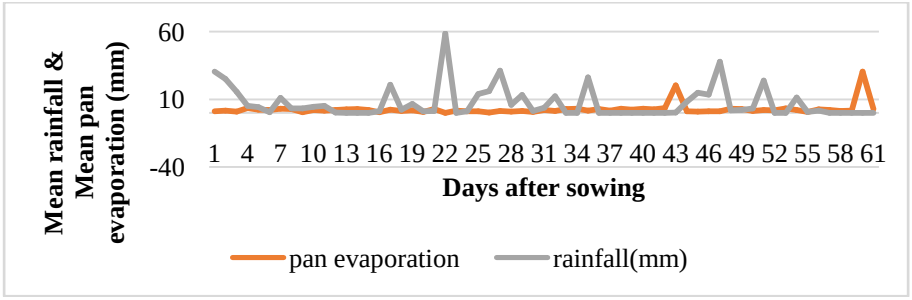

Figure 1: Fluctuation of mean rainfall (mm) and mean pan evaporation (mm) within the study period

Impact on morphological characters

Neither main effect of genotypes nor the interaction between genotypes and irrigation regime were significant ($p<0.05$), however significance was detected among the three irrigation regimes. Measured characters were far inferior in rainfed condition in contrast (Table 1). Between two irrigation regimes i.e. 14-16 and 21-24 days, canopy diameter, branch number and leaf area were similar, but interestingly, 14-16 days resulted quantitatively higher values. On contrary, plant height, and shoot length were significantly varied among 14-16 days irrigation regime and 21-24 days irrigation

regime, while establishing an interesting relationship. Plant height was greater in 14-16 days treatment, but shoot length was greater in 21-24 days interval (Table 1). Root fractions were similar in length and dry weight in both 14-16- and 21-24-days irrigation regime despite a marginal quantitative difference, and further both characters were more than 30% inferior in rainfed condition (Table 1).Significantly high root lengths were recorded within drought exposed irrigation regimes, 14-16 day and 21-24 days irrigation regimes in comparison to rainfed irrigation regime. Longer rooting depth aids to obtain stored water from several depths to improve stability in grain yield. Drought stressed plants diverted significantly higher dry matter to roots and stems to resist future events of moisture stress (Kumar and Sharma, 2009). Accordingly, root biomass of 16 days recorded the highest correlatively the highest yield as well (Table 1).

Lower leaf areas were recorded in 24 days than 16 days irrigation regime denoting water stress. (Table 1) It was resembled by depleted crop phenology, leaf area development, number of leaves per plant and finally results in low yield described by Abdel and Al-Rawi 2011). In response to severe moisture stress, crop in 24 days irrigation regime bloomed early flowers and thereby early pod set. Drought induces early flowering though it is not economical due to poor pod setting under drought stress (Ranawake *et al*. 2011). Thomas *et al*. (2004) reported that mungbean plants under water stress attained maturity earlier than the well-watered treatment.

Table 1: Morphological characters of mungbean genotypes at three irrigation regimes at 45DAS

Parameter	Rainfed (T1)	16 days (T2)	24 days (T3)	
Canopy Diameter	26.24^{B} (8.10)	48.61^{A} (10.94)	36.53^{A} (7.59)	***
Plant height	32.42^{C} (7.26)	71.11^{A} (14.23)	69.25^{B} (13.33)	***
Number of pods	7.33^{B} (3.63)	13.80^{A} (5.43)	14.61^{A} (5.99)	***
No of branches	6.80^{B} (1.58)	9.16^{A} (1.92)	8.54^{A} (2.63)	***
No of seeds per plant	12.86^{B} (17.17)	41.08^{A} (34.96)	46.88^{A} (33.89)	***
Root length	10.85^{B} (4.21)	14.38^{A} (4.47)	13.97^{A} (3.67)	***
Root dry weight	0.57^{B} (0.30)	0.79^{A} (0.33)	0.77^{A} (0.26)	***
Shoot dry weight	3.76^{C} (4.61)	11.18^{B} (3.58)	11.99^{A} (5.59)	***
Shoot length	9.71^{C} (3.02)	14.02^{B} (4.51)	18.75^{A} (6.04)	***
Leaf Area	220.1^{B} (137.94)	511.2^{A} (207.7)	472.5^{A}(137.9)	***
Leaf Dry Weight	1.77^{B} (0.88)	3.85^{A} (1.21)	4.03^{A} (2.10)	***

*values with the same letter are not significantly different at p<0.05 (LSD); ***Denote the significant difference at p<0.05; ns denote the non-significance; values in the parenthesis are the standard deviations*

Morphology of mungbean showed a greater variability in association to the degree of moisture stress imposed by each irrigation regime. Such variation may partly be explained by moisture stress; however, it was not only the moisture that matters. Rainfed condition was enough with moisture, hence plants should be free from drought stress (Figure 1). Inferior vegetative growth at rainfed conditions may be due to other different stresses like excess soil moisture, weed competition etc, prevailed outside of

rainout shelter rather than drought stress. Alternative wet and dry conditions that had prevailed outside of rain shelters may have a negative impact on plant growth in rainfed irrigation regime. In such instances, dry matter production could be restricted despite a limited amount of resourcefulness. (Hamid *et al.* 1988). Moreover, during vegetative growth of mungbean, sunlight was not adequate due to continuous rains and cloud cover. The rainout shelter had to be kept closed even during day times that made these plants to seek lighter always. Therefore, plants in 16 days irrigation regime and 24 days irrigation regime grew taller compared to plants in rainfed conditions. Often, plants grow under a shelter due to greenhouse effect showed higher stem elongation and canopy size (Muchow and Edwards, 1982).

Tolerance index

Tolerance index was calculated using a modified equation by Dutta *et al.*, (2008). Theoretically, a tolerance index less than 1.0 is indicated drought susceptibility, and a tolerance index greater than 1.0 indicates the drought enduring capabilities. In this study, drought enduring bench mark were also redefined i.e. 1.0-1.5 as mild drought endurance and >1.5 as superiors in drought enduring, thus the most elite varieties. (Dutta *et al.*,2008). At the time of estimating final yields 21-24 day (>80% ADL) crops were at physiological maturity, yet both rainfed and 14-16 days crops were still yielding.

Twelve genotypes were grouped below tolerance index of 1.0 and yield of the group was the highest under 14-16 days irrigation regime with a mean of 259.13 kg ha^{-1} and further the recorded lowest yield from rainfed condition was obtained from the same. Interestingly, a yield greater than 220 kg ha^{-1} was observed at 21-24 days irrigation regime, despite being high a deviation of more than 81 kg ha^{-1} was had being recorded (Table 2).

Table 2: Grouping of tested genotypes based on tolerance index and mean yield of each group at each irrigation regime

Tolerance Index	Inbred genotype/ Varieties				Rainfed (kg/ha)	16 days (kg/ha)	24 days (kg/ha)
<1	Ari	MIMB971	MIMB911	MIMB1022	136.0 (32.7)	259.1 (90.7)	223.7 (81.6)
	MIMB937	MIMB923	MIMB936	MIMB1005			
	MIMB914	MI6	MIMB907	MIMB940			
<1-1.5	MIMB902	MIMB921	MIMB1016	MIMB986	120.9 (41.4)	276.4 (61.6)	246.9 (71.9)
	MIMB1000	MIMB939	MIMB949	MIMB924			
	MIMB918	MIMB948	MIMB976	MIMB938			
>1.5	MIMB901	MIMB952	MIMB950	MI5	106.9 (28.9)	230.7 (69.8)	238.4 (62.2)
	MIMB953	MIMB908	MIMB945	MIMB922			
	MIMB1019			MIMB910			

Values in the parenthesis are the standard deviation of the mean

Genotypes that recorded a tolerance index from 1.0 – 1.5, a mild drought tolerant group had 12 genotypes. From this group, the highest mean yield was recorded for 14-16 day irrigation regime. However, yields were lower in both 21-24 days and 14-16 days irrigation regimes, and it was more than a 15 % drop. Inbred genotypes and varieties

showed a greater superiority in with a tolerance index more than 1.5. Yield of these genotypes were approximately similar in contrary to mild drought tolerant genotypes at rainfed. Quantitatively higher yield was recorded despite any significance between mild and superior tolerant groups (Table 2).

Total biomass, yield and harvest index

Total biomass, seed yield and harvest index were compared in order to understand the performance of inbred genotypes in different irrigation regimes. The highest total biomass was observed in 21-24 days irrigation regime and the lowest was observed in rainfed. Further, 14-16 days irrigation regime recorded substantially higher biomass, nevertheless the quantity was significantly lower to 24 days (Table 3). The highest seed yield was recorded in 14-16 days irrigation regime and no significant difference ($p>0.05$) was observed by 21-24 days, despite a low quantitative value. Unexpectedly, rainfed recorded the lowest on contrary (Table 3). However, HI was around 0.30-0.35, which was a typical HI of a legume. With restricted vegetative growth, HI of rainfed was more than 0.40, which was highly un-characteristic (Table 3). High intensity rainfall caused flower drop in rainfed irrigation regime and roots were inundated for long hours which would have confirmed yield reduced. On the contrary, 24 days irrigation regime also resulted an excessive flower drop due to low moisture stress causing a yield drop.

Table 3: Effect of different irrigation treatments on biomass, seed yield and harvest index

Irrigation regime	Rainfed (T1)	16 days (T2)	24 days (T3)	
Biomass (kg/ha)	296.4^{C} (63.5)	705.7^{B} (124.9)	786.0^{A} (192.1)	***
Seed yield (kg/ha)	122.1^{B} (36.03)	256.9^{A} (75.4)	236.2^{A} (71.4)	***
Harvest Index	0.41^{A}(0.09)	0.36^{B} (0.07)	0.30^{C} (0.08)	***

*values with the same letter are not significantly different at $p<0.05$ (LSD); ***Denote the significant difference at $p<0.05$; ns denote the non-significance; values in the parenthesis are the standard deviations*

There was no significant ($p>0.05$) yield difference between 16 days and 24 days irrigation regimes for some measured parameters. Time gap between two irrigationregimes may not have been sufficient enough to create an exact impact of drought stress. Even though, irrigation was done according to a schedule, soil moisture content by gravimetric method showed no significant difference between 16 days and 24 days irrigation regimes. This may associate to high soil moisture retention ability of Reddish Brown Earth (RBE) soil with high clay content (Mapa *et al*., 2005). The development of reproductive organs, which is under the control of photo-assimilate production and partitioning by the source tissues are most critical (Taiz and Zeiger, 2002; Wahid and Rasul, 2004). A 20 kg ha^{-1} yield difference between 16 days and 24 days irrigation regimes may have observed mainly due to high rate of floral and pod abortion (Liu *et al*. 2003).Even though highest biomass was recorded in 24 days irrigation regime with a satisfactory vegetative growth, translation of vegetative growth to yield was poor at stress with loss of reproductive parts (Baroowa and Gogoi, 2012).

Mean SPAD and IR values of mungbean genotypes

SPAD values during vegetative stage were low in contrast to other SPAD values in Flowering Stage & Pod filling Stage irrespective of irrigation regime (Table 4) Moreover, SPAD values of three irrigation regimes were similar at vegetative stage. The highest mean SPAD value was observed at the pod filling stage of mungbean under rainfed condition. This value was significantly higher than corresponding SPAD values of 14-16 and 21-24 days irrigation regime.(Table 4) which resembles the most severe moisture stress. Chlorophyll degradation may have occurred at stress causing low SPAD values. According to Netto *et al.* (2005), the indirect determination of chlorophyll content in leaves can be used as a tool to diagnose the integrity of the photosynthesis apparatus when the plants are subjected to environmental adversity. The reduction in leaf chlorophyll content generated by water shortage might be due to damage of photosynthetic apparatus causing from extreme swelling of chloroplast membranes, destruction of the lamellae vesiculation and the presence of lipid droplets (Farooq *et al.,* 2009). The construction of reactive oxygen species (ROS) an example O_2 and H_2O_2 triggering lipid peroxidation is one of the reasons for chlorophyll destruction under drought (Alaei, 2011).

Table 4: Mean SPAD values of mungbean genotypes at different growth stages at three different irrigation regimes

Growth stage	Rainfed (T1)	16 Days (T2)	24 Days (T3)	
Vegetative Stage	37.03^{A} (2.81)	37.20^{A} (2.91)	37.87^{A} (2.49)	NS
Flowering Stage	42.45^{A} (4.02)	44.58^{A} (5.15)	43.51^{A} (3.55)	NS
Pod filling Stage	46.57^{A} (6.85)	42.75^{B} (5.26)	40.24^{B} (4.93)	***

*values with the same letter are not significantly different at p<0.05 (LSD); ***Denote the significant difference at p<0.05; ns denote the non-significance; values in the parenthesis are the standard deviations*

During vegetative stage, 21-24 days irrigation regime recorded higher and similar IR value in comparison with the rainfed condition, but at 14-16 days, IR was significantly lower (Table 5). At pod filling, highest IR was recorded from rainfed conditions that is very similar to other two growth stages, and in addition 21-24 days recoded a similar (p>0.05) IR at pod filling. Lowest IR was observed from 14-16 days. High leaf temperature was recorded in rainfed than other two irrigation regimes, throughout the study may be due exposure of crop to direct sunlight outside the tunnel. High leaf temperature caused adversely on photosynthesis, and then on plant growth resulting an inferior growth of plants in rainfed irrigation regime.

Table 5: Mean IR values of mungbean genotypes at different growth stages at three different irrigation regimes

Date	Rainfed	16 Days	24 Days	
Vegetative Stage	23.87^{A} (1.01)	21.76^{B} (1.76)	23.24^{A} (1.89)	***
Flowering Stage	24.12^{A} (2.24)	19.63^{B} (2.39)	19.79^{B} (1.88)	***
Pod filling Stage	25.25^{A} (3.41)	21.47^{B} (2.27)	22.65^{B} (2.27)	***

*values with the same letter are not significantly different at p<0.05 (LSD); ***Denote the significant difference at p<0.05; ns denote the non-significance; values in the parenthesis are the standard deviations*

Principle Component Analysis score plots of three treatments

Measured plant and yield characters were used to construct principle components to limit the number of parameters by accounting a maximum variability. Several components were constructed and first two were used for preliminary screening process. In rainfed conditions, first two principle components were accounted a total of 72% variability, while 47% and 25% were the respective variability accounted by 1st two. With a third, cumulative variability accounted was more than 80% (In rainfed conditions, first principle component was driven by leaf dry weight and shoot length, while second was driven by number of seeds, number of flowers and total dry weight (Figure 4).There wasno drought stress in rainfed conditions, thus genotypes were screened considering performance of candidate genotypes in response to other environmental characters. Seven candidate genotypes were screened, which performed well under rainfed conditions. Mungbean genotype MIMB986, MIMB 1016, MIMB952, MI5, MIMB945 MIMB1022 and MIMB907 that were indicated by genotype number 29, 3, 16, 2, 7, 8 and 33 respectively were the best performing candidate genotypes in rainfed conditions (Figure 4). Mungbean genotype MIMB949, MIMB938, MIMB936, MIMB918 and MIMB940, which were indicated by genotype number 17, 19, 13, 4 and 20 showed far inferior performance in rainfed conditions.

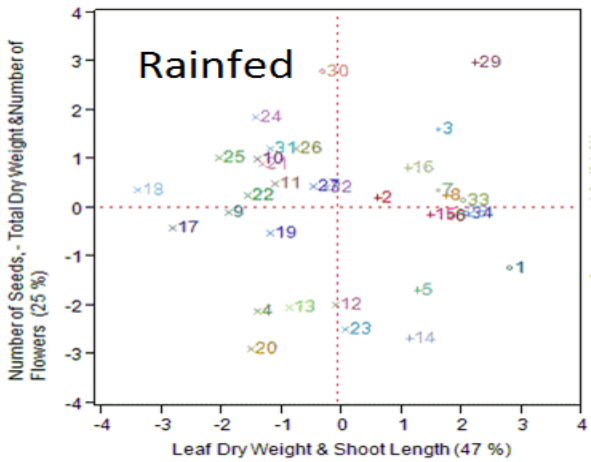

Figure 2: PCA score plot between first two components of 34 genotypes in rainfed conditions

Seven candidate genotypes that showed outstanding performances were screened in mild stress condition. Mungbean genotype MI5, MIMB976, MIMB986, MIMB907 and MIMB938, which were indicated by genotype number 2, 24, 29, 33 and 19 respectively were the best performing candidate genotypes in 16 days irrigation regime. Mungbean genotype MIMB908, MIMB1019, MIMB937, MI6, MIMB1000, MIMB918, 953 and MIMB971, which were indicated by genotype number 5, 12, 9, 1, 6, 4, 22, 23 and 14, had far inferior performance in 16 days irrigation regime (Figure 3).

In 24 day irrigation regime, first two components account a variability of 37.4% and 28.9% respective with a cumulative variability of 66.3%. With a third, cumulative

variability was increased up to 76.8% and a fourth was needed to describe cumulative variability more than 80% Frist component was driven by number of branches, leaf area, leaf dry weight and shoot length, while the second was driven by canopy diameter, root length and number of seeds.

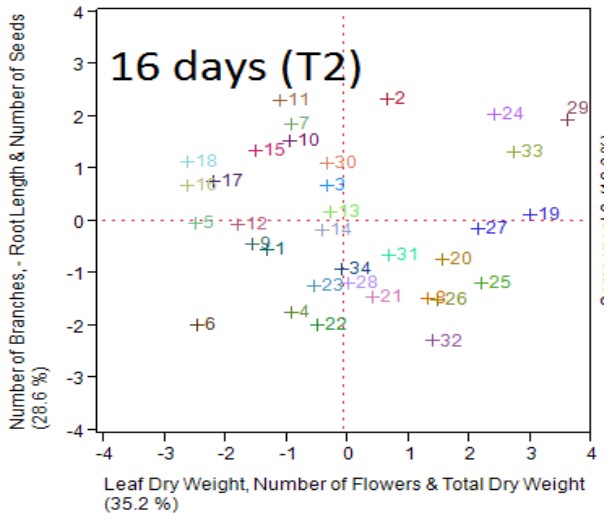

Figure 3: PCA score plot between first two components of 34 genotypes in 16 days irrigation regime

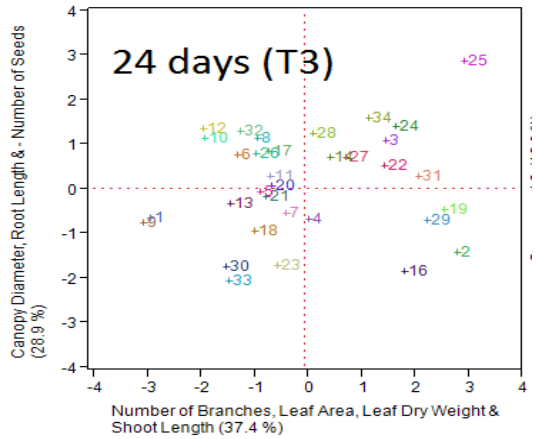

Figure 4: PCA score plot between first two components of 34 genotypes in 24 days irrigation regime

Nine candidate genotypes that showed outstanding performances were screened in severe stress condition. Mungbean genotype, MIMB901, MIMB910, MIMB976, MIMB902, MIMB922, Ari, MIMB1016, MIMB953 and MIMB921, which were indicated by genotype number 25, 34, 24, 28, 14, 27, 3, 22 and 31 respectively were the best performing candidate genotypes in 24 days irrigation regime. Mungbean genotype MIMB 939, MIMB936, MIMB945, MIMB948, MIMB971, MIMB914, MI6, MIMB937 and MIMB907, which were indicated by genotype number 21, 13, 7, 18, 23, 30, 1, 9 and 33 showed had far inferior performance in 24 days irrigation regime (Figure 4).

Conclusions

Impact of three irrigation regimes on growth and yield of thirty four mungbean genotypes were evaluated and this study exhibited a significant variation in most of morphological, physiological and yield characters between irrigation regimes and mungbean genotypes. Based on tolerance index, 10 elite genotypes namely MIMB901, MIMB908, MI5, MIMB910, MIMB953, MIMB950, MIMB922, MIMB952, MIMB1019 and MIMB945 were identified as drought tolerant genotypes. These genotypes could be used in crop improvement to develop varieties which can tolerate drought and produce higher yields either by releasing for cultivation or by breeding. Nine well performing mungbean genotypes were identified using the Principle Component Analysis as possible candidates for drought endurance namely, Ari, MIMB 901, MIMB 902, MIMB 922, MIMB 910, MIMB 976, MIMB 1016, MIMB 953 and MIMB 921.

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PHYSIOLOGICAL RESPONSES AND YIELD OF THREE OKRA (*Abelmoschus esculentus* L.) CULTIVARS AS AFFECTED BY SOIL MOISTURE STRESS DURING THE FLOWERING STAGE

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Abstract

Drought being the most important environmental stress severely impairs plant growth and development, limits plant production and the performance of crop plants more than any other environmental factor. In concern with this, an experiment was conducted to assess moisture stress responses of three okra cultivars on selected physiological attributes and yield when the stress was imposed during the flowering stage and to select the most suitable okra cultivar which can resist drought and produce substantial yield under water deficit condition. The okra cultivars were grown in one hundred and ninety-two polyethylene bags (36 cm height and 45 cm diameter). Moisture stress was imposed for the three okra cultivars for a period of ten days during the flowering stage by withholding water completely at once. This experiment was laid out in the Randomized Complete Block Design with six treatments and four replications and the treatments were arranged in 3 × 2 factor factorial manner. There were significant ($p < 0.05$) differences between treatments in the measured physiological attributes and yield of okra cultivars under moisture stress condition. The highest Relative Water Content (63.4%) was obtained in 'EUOK 2'okra cultivar and the lowest (39.0%) was found in 'MI 5'. The highest values of 'Chlorophyll a' (0.75 mgg^{-1}), 'Chlorophyll b' (0.77 mgg^{-1}) and 'total Chlorophyll' (1.6 mgg^{-1}) were recorded in 'EUOK 2'okra cultivar and the lowest 'Chl. a' (0.19 mgg^{-1}), 'Chl. b' (0.23 mgg^{-1}) and 'total Chlorophyll' (0.52 mgg^{-1}) were recorded in 'MI 5'. The highest yield (3.8 tha^{-1}) was obtained in 'EUOK 2'okra cultivar and the lowest (0.6 tha^{-1}) was found in 'MI 5'. From these results, it was found that 'EUOK 2' okra cultivar has produced the highest physiological attributes and yield than the others under drought condition and hence, it was identified as the most drought resistant okra genotype among the tested ones.

Keywords: Chlorophyll content, Moisture stress, Okra, Relative Water Content, Yield

Introduction

Plant growth and development as well as crop production are highly influenced and sometimes limited by environmental conditions such as drought, salinity and temperature stresses. Among these, drought stress is the most important environmental constraint to world agricultural production (Bray *et al*., 2000). The overall plant responses to the abiotic stresses could be generalized into morphological, physiological and biochemical responses (Fahad *et al*., 2017). Drought induced changes are mainly

related to altered metabolic functions such as reduced synthesis of photosynthetic pigments (Batra *et al*., 2014), accumulation of osmo protectants like proline in the cell (Ashraf and Harris, 2004), decline in cell membrane integrity and alterations in physiological parameters such as reduced leaf water content (Baroowa and Gogoi, 2015).

Exposure of plants to soil moisture stress substantially decreased the Leaf Water Potential, Relative Water Content and Transpiration Rate with a concomitant increase in leaf temperature (Siddique *et al*., 2000). Relative Water Content is an important characteristic feature that influence plant water relations. It is considered a measure of plant water status reflecting the metabolic activity in tissues and used as the most meaningful index for dehydration tolerance (Anjum *et al*., 2011). Appraisal of water relations in plants grown under moisture stress condition is necessary to ascertain that up to what extent cellular water content is maintained because almost all metabolic activities within the cell are dependent on the availability of sufficient amount of water therein (Ashraf *et al*., 2011).

The measurement of Relative Water Content under low soil moisture is of importance since high Relative Water Content appears to be a common trait in drought resistant species as species which exhibit restricted changes in Relative Water Content per unit reduction in water potential are often considered to be relatively drought resistant (Rahaman *et al*., 2000).

Drought damages the photosynthetic pigments and the thylakoid membranes (Anjum *et al*., 2011). The reduction in Chlorophyll content under drought has been reported (Din *et al*., 2011). It seems to depend on crop and cultivar type. For instance, Chlorophyll contents in some cultivars of black gram were increased while in some others they were decreased under moisture stress (Ashraf and Karim, 1991). This varied behavior was attributed to the variation in the activities of enzymes involved in chlorophyll biosynthesis. It has been reported that concentration of 'Chlorophyll a' was higher as compared to 'Chlorophyll b' in drought stressed plants (Jain *et al*., 2010).

Okra (*Abelmoschus esculentus* L.) is one of the most important warm season fruit vegetables grown throughout the tropics and valued for its edible green pods that are popular vegetables in Sri Lanka ranked fourth in cultivated extent (Anon, 2007). It is cultivated in the dry zone as a mono crop in irrigated uplands and rice-based cropping systems during the '*Yala*' season and also in well drained highlands during the '*Maha*' season. Okra plants are characterized by indeterminate growth. Flowering continues but highly dependent upon biotic and abiotic stresses. Matlob *et al*. (1989) have indented the importance of time of irrigation and number of irrigations (irrigation interval) in increasing the yield and quality of okra. Okra is reported to be comparatively drought tolerant (Singh *et al*., 2014) but, drought can reduce yield depending on severity (Romaisa *et al*., 2015). In okra, the stages of reproductive development prior to flowering, at flowering and at early pod development are particularly sensitive to moisture stress. It causes adverse effects on water relations, growth, metabolism, mineral nutrition and yield.

Okra cultivation in the Batticaloa district is heavily affected by drought. It is therefore necessary to study the growth performance of different okra cultivars under moisture stress condition. Hence, the present study was conducted with the objectives of determining the effects of soil moisture stress during the flowering stage on the physiological attributes and yield of three okra cultivars, comparing the physiological performance of these cultivars under moisture stress condition and identifying the most drought resistant okra cultivar which can resist drought and produce substantial yield under water limited situation.

Materials and Methods

This experiment was conducted at the Agronomy farm of the Eastern University, Sri Lanka from June to September 2018. The type of soil of this area is sandy regosols. The altitude of the site is around 100 m above mean sea level and it comes under the Agro-ecological zone of Low Country Dry Zone (DL2b). The annual mean temperature varies from 28 to 32°C and the humidity ranges from 60 to 90%. The mean annual rainfall of this district is between 1800 to 2100 mm.

Black polyethylene sheets having the thickness of 500 gauge were used to prepare the bags. A number of one hundred and ninety-two polyethylene bags (36 cm height and 45 cm diameter) were made for this experiment. These bags were filled with the potting mixture of top soil, red soil and compost at the ratio of 1:1:1. Basal dressing of fertilizers Urea (32.3 $gbag^{-1}$), Triple Super Phosphate (126.9 $gbag^{-1}$) and Muriate of Potash (16.2 $gbag^{-1}$) was done two days before sowing. The okra seeds cvs. 'Haritha', 'MI 5' and 'EUOK 2' were sown in these bags. The first top dressing (Urea – 20.4$gbag^{-1}$) was done at two weeks after sowing. The second (20.4$gbag^{-1}$) and third (16.3 $gbag^{-1}$) top dressings were done on the 5^{th} and 8^{th} week after sowing respectively. Watering was done daily in the morning and evening until germination. Thereafter, it was applied at two days interval to Field Capacity.

Soil moisture stress was imposed for the selected okra cultivars for a period of 10 days during the flowering stage by withholding water completely at once. The control plants were watered at two days interval to Field Capacity. The experiment was laid out in the Randomized Complete Block Design with 3×2 factor factorial arrangement having six treatments and four replications and the treatments were as follows:

T1 = Regular watering for the 'Haritha' okra cultivar at two days interval to Field Capacity- Control

T2 = Moisture stress was imposed for the 'Haritha' cultivar for 10 days during the flowering stage.

T3 = Regular watering for the 'MI 5' okra cultivar at two days interval to Field Capacity- Control

T4 = Moisture stress was imposed for the 'MI 5' cultivar for 10 days during the flowering stage.

T5 = Regular watering for the 'EUOK 2' okra cultivar at two days interval to Field Capacity- Control

T6 = Moisture stress was given for the 'EUOK 2' cultivar for 10 days during the flowering stage.

Rain shelters were erected above the experimental area to prevent the entry of rain water into the experimental field.

Determination of soil moisture content

The soil moisture content of the water stressed soil in the bags was determined on dry weight basis using a soil co-sampler. The soil samples were collected at a depth of 30 cm from the surface of the soil on the 10th day from the commencement of the stress. The fresh weights of the samples were measured by an electronic balance (Ohaus PA313). The dry weights were determined by using an oven at 105°C for two days. The soil moisture content was calculated on percentage basis as follows:

$$\text{Soil moisture content (\%)} = \frac{Fw - Dw}{Fw} \times 100$$

Where, Fw = Fresh weight of the soil sample

Dw = Dry weight of the soil sample

Physiological measurements

Relative Water Content

A number of two leaves representing two plants were randomly collected from each replicate of the treatments and the Relative Water Content was determined as follows:

The leaves were cut into 10 discs of 1cm diameter each and were weighed to determine the Fresh Weight (FW). These discs were immersed in distilled water for 24 hours, removed from water and were blotted by filter papers. These discs were then weighed to determine the Turgid Weight (TW) and the samples were dried by an oven at 80°C for 24 hours to record the Dry Weight (DW). The Relative Water Content was calculated as follows:

$$\text{Relative Water Content (\%)} = \frac{FW - DW}{TW - DW} \times 100$$

Chlorophyll content

The Chlorophyll content of the okra leaves was estimated as described by Smith and Benitez (1955). A number of two leaves representing two plants were randomly collected from each replicate of the treatments and were washed thoroughly with water, blotted with filter papers and were cut into small pieces. A quantity of 1g of fresh leaf sample was weighed by an electronic balance and was macerated by a mortar and pestle with the addition of 10 ml of 80% acetone (w/v). The homogenate was then centrifuged (Heraeus Pico 17 Micro centrifuge) at 5000 rpm for 10 minutes and the supernatant was collected. The residues were washed again with 80% acetone and were centrifuged. This process was repeated again and the final volume of the pooled supernatant was collected. The optical density of the Chlorophyll extract was recorded by a spectrophotometer (BK-V1600 VIS) at 646, 663 and 750 nm wavelengths using 10 mm cuvettes. The amount of Chlorophylls present in the leaf extract was estimated as follows:

Mg 'Chlorophyll a' g^{-1} tissue = $\frac{[\,12.7\,(OD663) - 2.69\,(OD645)]\times V}{1000\times W}$

Mg 'Chlorophyll b' g^{-1} tissue = $\frac{[\,22.9\,(OD645) - 4.68\,(OD663)]\times V}{1000\times W}$

Mg 'Total Chlorophyll' g^{-1} tissue = $\frac{(\,OD652\times 1000)\times V}{34.5\times 1000\times W}$

Where,
OD = Optical density reading of the Chlorophyll extract at the specific wavelength
V = Final volume of the 80% acetone – Chlorophyll extract
W= Fresh weight of the tissue (g)

Yield
A number of two plants were randomly collected from each replicate of the treatments and the pods of these plants were collected on alternate days from the first to the eighth harvest. The fresh weights of these pods were recorded.

Statistical Analysis
The data were statistically analyzed and the difference between treatment means was compared using DMRT.

Results and Discussion

The average soil moisture content of the water stressed soil in the polyethylene bags at a depth of 30 cm from the surface of the soil was 10.4%.

Relative Water Content (RWC)
There were significant ($p < 0.05$) differences between treatments in the RWC of okra cultivars 'Haritha', 'MI 5' and 'EUOK 2' when moisture stress was imposed during the flowering stage (Table 1).The highest RWC was obtained in 'EUOK 2' okra cultivar and the lowest was found in 'MI 5' under moisture stress condition. Moisture stress therefore has reduced the RWC of all the tested okra cultivars. The pronounced reduction of RWC when water lack occurs at flowering stage of okra is also observed by Nana *et al*., (2014).

A decrease in RWC in response to drought stress has also been noted in wide varieties of plants as reported by Nayyar and Gupta (2006). According to Srinivasa Rao and Bhatt (1988), as soil water content decreases, plant water status declines. Hence, leaf water content ultimately decreases in the stressed plants. Leaf cells shrink and water content reduces. Transpiration rate and relative water content decline with slight changes in leaf water potential.

Table 1: Effects of soil moisture stress during the flowering stage on the relative water contents (RWC) of three Okra (*Abelmoschus esculentus* L.) cultivars

	Cultivars	Treatments	RWC %
No stress	'Haritha'	T1	65.7 a
	'MI 5'	T3	61.0 a
	'EUOK 2'	T5	67.3 a
Stress	'Haritha'	T2	52.7 b
	'MI 5'	T4	39.0 c
	'EUOK 2'	T6	63.4 a

Values in the same column followed by the same letter do not differ significantly ((p <0.05). Values are the means of 8 plants in 4 replications.

Chlorophyll content

There were significant (*p <0.05*) differences between treatments in the Chlorophylls a, b and total Chlorophyll contents of leaves of 'Haritha', 'MI 5' and 'EUOK 2' okra cultivars when moisture stress was imposed during the flowering stage (Table 2). The highest Chlorophylls a, b and total Chlorophyll contents were obtained in 'EUOK 2' okra cultivar and the lowest was found in 'MI 5' under moisture stress condition.

Table 2: Effects of Soil Moisture Stress during the Flowering Stage on the Chlorophylls a, b and Total Chlorophyll Contents of Three Okra (*Abelmoschus esculentus* L.) Cultivars

	Cultivars	Treatments	Chl. a (mgg^{-1})	Chl. b (mgg^{-1})	TotalChlorophyll (mgg^{-1})
No stress	'Haritha'	T1	0.93 a	0.89 a	1.9 a
	'MI 5'	T3	0.55 b	0.53 b	1.2 b
	'EUOK 2'	T5	0.91 a	0.86 a	1.8 a
Stress	'Haritha'	T2	0.62 b	0.64 b	1.2 b
	'MI 5'	T4	0.19 c	0.23 c	0.52 c
	'EUOK 2'	T6	0.75 a	0.77 a	1.6 a

Values in the same column followed by the same letter do not differ significantly ((p <0.05). Values are the means of 8 plants in 4 replications.

Moisture stress has therefore reduced the Chlorophyll contents of all the tested okra cultivars. Low concentrations of photosynthetic pigments can directly limit photosynthetic potential and hence primary production. Chlorophyll formation, the major biochemical process in green plants such as okra is diminished under drought condition. This has been attributed to the fact that when under abiotic challenge, plant biochemical processes are distracted toward production of osmoprotectants and other antioxidant proteins for survival and this is usually achieved at the expense of other metabolic activities (Blum, 2011). From a physiological perspective, leaf Chlorophyll content is a parameter of significant interest in its own right. As pointed out by Anjum *et al*. (2011), the decrease in chlorophyll content under drought stress has been considered a typical symptom of oxidative stress and may be the result of pigment photo oxidation and Chlorophyll degradation. Photosynthetic pigments are important to plants mainly for harvesting light and production of reducing power. As stated by

Farooq *et al*. (2009), both, the Chlorophylls a and b are prone to soil dehydration.Our results are in agreement with Adejumo *et al*. (2018) where the okra cultivar 'NHAe 47-4' when subjected to water deficit conditions at the reproductive stage showed reduced total chlorophyll content. Decline in the Chlorophylls a, b and total Chlorophyll during drought stress also exhibited by plants *viz.* sunflower (Manivannan *et al*., 2007) and pigeon pea (Devi and Sujatha, 2014). Water deficit stress destroys the Chlorophyll and prevents its biosynthesis (Lessani and Mojtahedi, 2002). The highest values of Chlorophylls a, b and total Chlorophyll observed in EUOK 2 under moisture stress situation would have been due to the Chlorophyll retention property of this cultivar under drought condition.

Yield

There were significant ($p < 0.05$) differences between treatments in the fresh pod weights of 'Haritha', 'MI 5' and 'EUOK 2' okra cultivars when moisture stress was imposed during the flowering stage (Table 3). The highest yield was obtained in 'EUOK 2' and the lowest was found in 'MI 5'under moisture stress condition. Moisture stress therefore has reduced the fresh pod weights of all the tested okra cultivars.

Table 3: Effects of soil moisture stress during the flowering stage on the fresh pod weights of three Okra (*Abelmoschus esculentus* L.) cultivars

	Cultivars	Treatments	Fresh Pod Yield(tha^{-1})
No stress	'Haritha'	T1	9.9 a
	'MI 5'	T3	2.2 c
	'EUOK 2'	T5	7.0 b
Stress	'Haritha'	T2	2.6 b
	'MI 5'	T4	0.6 c
	'EUOK 2'	T6	3.8 a

Values in the same column followed by the same letter do not differ significantly ($p < 0.05$).
Values are the means of 8 plants in 4 replications.

The yield of okra is influenced by the availability of soil moisture during vegetative and reproductive stages and crop experiencing drought during the reproductive phase shows significant ($p < 0.05$) yield reduction. Drought stress during reproductive stages like flowering and podding is crucial for yield in okra and this reduction of crop yield depends on okra varieties and tolerant genotypes will be able give better yield considerably due to physiological and biochemical changes that are triggered during drought stress. Adejumo *et al*. (2018) stated that water deficit duration longer than 10 days at the reproductive stage especially at 25% field capacity could be detrimental to okra growth and yield.

Vaidya *et al*. (2015) have indicated reduction of yield due to drought stress and it was highly significant ($p < 0.05$) between genotypes, drought stress and their interaction. It seems that a balanced intake of water during various developmental stages of okra can improve pod yield. The highest yield obtained in 'EUOK 2' cultivar compared to the others under moisture stress condition reflects its inherent drought tolerance feature. Gama *et al*. (2009) indicated that changes in water relations of plants that are stressed

could be seen in certain studies which confirmed that many plants undergo reduced plant water status when they are exposed to drought stress. The highest RWC obtained in 'EUOK 2' okra cultivar under moisture stress condition would have been due to its inherent drought resistant property. Cultivars which are believed to be more drought resistant usually maintain higher leaf RWC under drought condition.

Conclusions

Soil moisture stress imposed during the flowering stage has reduced the physiological attributes and yield of tested okra cultivars. The highest physiological performance in terms of Relative Water Content, Chlorophylls a, b and total Chlorophyll contents and yield was obtained in 'EUOK 2' okra cultivar and the lowest of these was found in 'MI 5' under moisture stress condition. Hence, 'EUOK 2' was identified as the drought tolerant okra cultivar among the tested ones which can resist drought and produce substantial yield under water scarce situation in the sandy regosols of the Batticaloa district.

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LABORATORY EVALUATION OF SOME SELECTED INDIGENOUS PLANT LEAF AND GARLIC BULB EXTRACTS AGAINST *Tribolium castaneum* (Coleoptera: Tenebrionidae) IN CHICKPEA (*Cicer arietinum*)

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Abstract

Globally red flour beetle, *Tribolium castaneum* is the foremost limiting factor to profitable storage of pulse grains. The effect of leaf extracts of nochi (*Vitex negundo*), eucalyptus (*Eucalyptus globulus*), neem (*Azadirachta indica*), anona (*Annona squamosa*) and extract of garlic (*Allium sativum*) was evaluated as grain protectant based on adult mortality, grain damage and new emergence of *T. castaneum* in chickpea. The extract of garlic bulb 10% significantly superior in controlling *T. castaneum* however neem 10% also proved its efficacy with 100% mortality of the weevil at 4th week after the treatment and showed significantly ($p \leq 0.01$) most effective in controlling seed damage and new emergence of weevils than other treatments. In untreated control, the percentage of damaged grains and number of new progenies gradually increased until the 18th week with significantly very low mortality in *T. castaneum*. The survival of *T. castaneum* in the grains treated with nochi 10% and anona 10% were noted until 10th weeks, thereafter 100% mortality was caused by these botanicals and thus damage was completely controlled in the grains. Furthermore, the leaf extract of eucalyptus showed significantly least efficient for protecting chickpea grains from the infestation of *T. castaneum*.

Keywords: Control, Damage, Leaf extracts**,** Mortality, *Tribolium castaneum*,

Introduction

Chickpea is an essential pulse crop cultivated all over the world predominantly in the Afro-Asian countries (Jukanti *et al.,* 2012). Among these, India is the large-scale chickpea producing country and accounting for 66% of global chickpea production (FAOSTAT, 2011). Even though the pulse grains such as cowpea, black gram, green gram and soybean are grown in Sri Lanka for their needs (Wijeratne, 2012; Nugaliyadda and Babu, 2013) chickpea is not grown highly in Sri Lanka due to its major constraints like vulnerability to high temperature and terminal drought, however, chickpea is consumed widely in Sri Lanka, and the whole demands are met through imports (Anon, 2004).

As it is known, chickpea is an important cereal grain for starch food, every year it is being fell down its demands by various storage pests. Among them, *T. castaneum* is one of the major starch dependent storage pests, which is accountable for drastic stored

grain losses and this insect causing up to 40% reduction in stored grains in storage periods (Ajayi and Rahman, 2006; Rees, 2007).

Currently low and middle income countries are using chemical insecticides such as chlorinated hydrocarbon, organophosphorus, pyrethroids and fumigants to putting down the populations of stored pest which may bring into risk for human and animal health as well as agro- ecosystem (Ahmed *et al*., 2008). Therefore, continuous use of chemical pesticides have issued in serious problems like insecticide resistance and it may be led to lethal effect on non-target organisms and toxicity to user (Okonkwo and Okoye, 1996; Mohan *et al.*, 2010). At present as the chemical pesticide increase over the level of pesticide residues in food (Said and Pashte, 2015), the grain managers tend to look only at chemical alternative to control stored grain insects (Flinn and Hagstrum, 2001). In this case, the trend is now towards the use of botanicals having insecticidal properties and is relatively cheaper than synthetic pesticides (Shadia, 2011; Islam *et al.*, 2016). With this background the efficacy of some plants, which are available in the eastern region of Sri Lanka have been evaluated as alternative, eco-friendly and relatively cheaper ways to manage the problem of red flour beetle in stored pulse chickpea.

Materials and Methods

A laboratory experiment was carried out at the General Laboratory of the Department of Agricultural Biology, Faculty of Agriculture, Eastern University Sri Lanka from September 2017 to February 2018. As protectant of stored chickpea, the leaf extracts of four plants *viz.*, nochi (*Vitex negundo*), eucalyptus (*Eucalyptus globulus*), neem (*Azadirachta indica*) and anona (*Annona squamosa*) as well as bulb extract of garlic (*Allium sativum*) were treated to chickpea grains against the insect pest, *T. castaneum*.

Preparation of Botanical Pesticides

An amount of one kilogram of leaves of neem, nochi, eucalyptus and anona were taken from the agronomy farm of Eastern University, Sri Lanka, and 250 g of garlic bulbs were bought at the shop nearby the University. Collected leaves and bulbs were ground separately in to fine particles by using domestic mixing grinder and put into the mud pots separately. Five liters of cow urine was added to each of the mud pot containing leaf and bulb extracts. The mouth of each mud pot containing each of the botanical preparation were tied with cotton cloth and buried under the soil for seven days. After seven days the soaked solution was filtered using a cotton muslin cloth and stored in an amber colour bottle. Each botanical was diluted at the rate of 1:10 at the time of usage (Anon. 2010).

Experimental methods

Six thousand numbers of chickpea grains were taken and thoroughly cleaned and exposed in an oven dried under the condition of 60°C for about 6 hours to ensure the absence of insects, mites and disease causing microorganisms. The sterilized seeds were divided into six seed lots each containing thousand chickpea grains. Each seed lot

was separately treated with each of the diluted botanical solution *viz*., leaf extracts of neem 10%, anona 10%, nochi 10%, and eucalyptus 10% and bulb extract of garlic 10% and untreated control (a seed lot treated with water only). The treated and untreated seed lots were air dried under shaded condition.

Each of the treated and untreated seed lot consisting thousand chickpea grains was further grouped into four as one contained two hundred and fifty grains in order to set 4 replications. Each seed lot was kept in a gunny bag and introduced with 10 adult *T. castaneum*. After the introduction of stored pest, the treated and untreated gunny bags were tightly tied with thread to prevent the movement of insects from inside to outside or vice versa.

Percentage mortality of *T. castaneum*, the number of chickpea grains damaged and new emergence of *T. castaneum* were recorded fortnightly. The percentage of mortality was calculated by following equation;

$$\text{Percentage of mortality} = \left[\frac{\text{Number of insects died}}{\text{Number of insects died} + \text{Number of insects alive}}\right] \times 100$$

Data Analysis
One-way ANOVA was performed using SAS 9.1 version and mean comparison was done by Duncan's Multiple Range Test. All the comparisons were considered significant when $p \leq 0.01$.

Results and Discussion

Effect of some indigenous leaf and garlic extract on red flour beetle (Tribolium castaneum)

Percentage adult mortality of T. castaneum
Table 01 provides the percentage mortality of *T. castaneum* in stored chickpea treated with botanical pesticides. Significantly ($p \leq 0.01$) highest mortality was observed in garlic (65.0%) treated chickpea in 2nd week after treatment followed by neem (45.5%) and anona. Eucalyptus treated chickpea showed a least significant in controlling the *T. castaneum*.

Though the studies on efficiency of botanicals against *T. castaneum* on chickpea are rare, the present study has been discussed with the studies carried out on efficiency of botanicals against *T. castaneum* on different other hosts. The study of Patil *et al*., (2015) stated that the application of neem seed powder at 5g would be an efficacious treatment with respect to killing of *T. castaneum* in stored rice followed by black pepper seed powder at 5 g for protecting the rice grains. The authors also observed the substantial reduction of the population of *T. castaneum* in stored rice by the application of karanj (*Pongamia pinnata*), tulsi (*Occimum basilicum*), turmeric rhizomes (*Cucurma longa*), onion (*Allium cepa*)and garlic (*A. sativum*).Further Mamun *et al.*, (2009) also reported that the neem seed extract had highest toxic effect (52.50 %

mortality), whereas, Hijal (*Barringtonia acutangula*)leaf extract possessed the lowest toxic effect (22.24 % mortality) against *T. castaneum*.

Table 1: Mean percentage mortality of *Tribolium castaneum*

Treatment	*Mortality%								
	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week	18th week
Nochi (*Vitex negundo*)	20.0c	40.0 b	70.0 b	90.0 b	100.0a	100.0a	100.0a	100.0a	100.0a
Eucalyptus (*Eucalyptus globulus*)	10.0d	30.0 b	50.0 c	50.0 c	60.0 b	60.0b	60.0b	60.0b	60.0b
Neem (*Azadirachta indica*)	45.5b	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a
Anona (*Annona squamosa*)	30.0b	40.0 b	60.0 c	80.0 b	100.0a	100.0a	100.0a	100.0a	100.0a
Garlic (*Allium sativum*)	65.0a	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a	100.0a
Control	0.0 e	20.0 c	30.0 d	30.0 d	30.0 c	30.0 c	30.0 c	30.0 c	30.0 c

**Values were subjected to arcsine transformation*
Means followed by same letter in each column do not differ statistically at $p \leq 0.01$ based on DMRT

Percentage of chickpea damaged by T. castaneum

The results on percentage of damaged chickpea are shown in table 2. A significant difference was observed between the percentages of seed damage in different treatments. The damage was not visible in the grains treated with garlic however significantly least (1.2%) damage was noted in the grains treated with neem and it was completely limited after 6th weeks of treatment. The damage by *T. castaneum* was increased throughout the study period in untreated control and reached a maximum of 81.2% at 18 weeks after treatment followed by eucalyptus where 30% of loss was recorded in 14 weeks after treatment.

Table 2: Percentage of damaged chickpea recorded with each botanical extract and cow urine mixture

Treatment	*Percentage of damage grains								
	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week	18th week
Nochi (*Vitex negundo*)	0.0a	1.6c	1.8c	2.6c	2.6c	2.6c	2.6c	2.6c	2.6c
Eucalyptus (*Eucalyptus globulus*)	1.6c	6.4f	6.8e	10.8e	16.6e	20.8e	30.0e	30.0e	30.0e
Neem (*Azadirachta indica*)	0.0a	0.4b	1.2b	1.2b	1.2 b	1.2b	1.2b	1.2b	1.2b
Anona (*Annona squamosa*)	0.8b	2.8d	5.2d	7.2d	7.2d	7.2d	7.2d	7.2d	7.2d
Garlic (*Allium sativum*)	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0 a	0.0a	0.0a
Control	2.0d	5.6e	8.0f	14.4f	22.8f	34.8f	44.0f	72.f	81.2f

**Values were subjected to arcsine transformation*
Means followed by same letter in each column do not differ statistically at $p \leq 0.01$ based on DMRT

Number of development of progeny

The new progeny of *T. castaneum* is shown in table 3. After 30 days onward the development of new progeny of *T. castaneum* was observed in control treatment and it was increased day by day until 113 of the last reading, which revealed the host preference of *T. castaneum* towards chickpea. Furthermore, significantly minimum number of new emergences was observed in anona and eucalyptus treated seeds and it was stopped after 8th and 12th weeks onwards. None of the progenies of *T. castaneum* have been noted in nochi, neem and garlic treated grains.

Table 3: Effect of botanicals on number of adult emergence

	*Number of adult emergence								
Treatment	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week	18th week
Nochi (*Vitex negundo*)	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Eucalyptus (*Eucalyptus globulus*)	0.0 a	0.0 a	0.0 a	3.0 b	3.0 b	9.0 c	9.0 c	9.0 c	9.0 c
Neem (*Azadirachta indica*)	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Anona (*Annona squamosa*)	0.0 a	0.0 a	2.0 b	3.0 b	3.0 b	3.0 b	3.0 b	3.0 b	3.0 b
Garlic (*Allium sativum*)	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
Control	0.0 a	0.0 a	10.0 c	21.0 c	34.0 c	45.0d	61.0d	93.0d	113.0d

**Values were subjected to square root transformation.*
Means followed by same letter in each column do not differ statistically at $p \leq 0.01$ based on DMRT

Inamullah *et al.* (2016) revealed that the development of new emergence of *Tribolium* beetle was significantly low when the different concentration of the tested plants, *Verbana tenuisecta, Parthenium hysterophorus, Calotropis procera* and *Azadiracta indica* were added to the flour. The extracts of *V. tenuisecta* (at 500 ppm) effectively controlled egg laying of *T.castaneum*, i.e., the minimum mean number of eggs was 61.00, followed by the standard *A. indica* at 1000 ppm with 77.50 eggs. Further the comparative insecticidal activity of different plants were evaluated against *T.castaneum* earlier by Ahmed *et al*, (2018) in Pakistan, the results have recommended that *A.sativam* (garlic) and *Z. officinale* (ginger) were more effective resulting in to 15 times higher adult mortality and 4 to 5 times reduction in grain weight losses when mixed with rice grain.

Meanwhile, the researchers Gunarathna and Karunaratne, (2009) in Sri Lanka, evaluated thirty-seven Sri Lankan plants as post-harvest grain protectants for the control of rice weevil *Sitophilus oryzea*. The results revealed that, out of these twenty plants *Ocimum gratissimum* (Lamiaceae), *Cinnamomum verum* (Lauraceae), *Mentha viridis* (Laminaceae), *Plectranthus amboinicus* (Laminaceae) and *Citrus reticulate* (Rutaceae) showed highest repellent activity whereas *M.viridis* elicited the highest and

strongest repellency (89.0%) against the weevils when compared with the other treatment.

Conclusions

The application of garlic (*Allium sativum*) and neem (*Azadirachta indica*) were effective treatments with respect to the mortality of *Tribolium castaneum* as well as suppress the new progeny and completely control the seed damage of chickpea in storage condition. The botanicals nochi (*Vitex negundo*) and anona (*Annona squamosa*) also protected the chickpea as much as possible whereas eucalyptus (*Eucalyptus globulus*) provided a least protection against *T. castaneum*.

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PESTICIDE RESIDUE ANALYSIS IN OKRA IN BATTICALOA DISTRICT

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Abstract

Accretive agriculture sector in the world has led a worldwide concern on food safety and enforcement of strict pesticide regulations. Batticaloa district located in the Eastern Province of Sri Lanka where, farmers are suspected to use synthetic and cocktailed pesticide in high frequencies and high dosages. Okra is one of the major crops cultivated in Batticaloa district. Thus this study was conducted to determine the farmers' common agriculture practices and to perform pesticide residue analysis in okra. A questionnaire survey was conducted by using 40 farmers including farmers from whom the samples were collected for residue analysis. The survey results revealed that none of the okra farmers followed the recommended practices while applying pesticides due to lack of awareness and unavailability of a monitoring mechanism. 20 okra field samples and 9 market samples were analyzed to determine 20 pesticide residues by using Gas *Chromatography*-Triple *Quardrupole* Mass *Spectrometry* (GC-MS-MS) analysis. The samples were extracted according to AOAC official method 2007.01 by using single step buffered acetonitrile extraction and salting out liquid to liquid partitioning of water in the sample with $MgSO_4$. Dispersive solid phase extraction cleanup was done by using primary secondary amine and $MgSO_4$. Presence of pesticide was confirmed by using retention time and mass spectrum. Analyzed reports revealed that none of the okra samples were contaminated with pesticide which were analyzed. Reported residue levels were compared with European Union legislation on Maximum Pesticide Residues Limits (EU MRL). The study also recommended to analyze the residue of pesticides that frequently used by farmers including banded and restricted pesticides in Sri Lanka for vegetables cultivation in Batticaloa and other districts.

Key words: GC-MS-MS, Maximum Residual Limits, Okra, Pesticide.

Introduction

Batticaloa district in the Eastern Province and that falls under dry zone climatic conditions which has average rainfall about 1756 mm and average temperature about 27.4 ^{0}C (Climate-Data-Org). There are 14 Divisional Secretariat (DS) Divisions in the Batticaloa district. Farmers in this area use variety of synthetic pesticides to protect vegetable crops from pests and diseases. Manmunai south and Eruvil pattu is the

highest vegetable growing DS Division in the Batticaloa district. Brinjal and okra is one of the major crop cultivate in the Batticaloa district (Sutharsan *et al*., 2014). Pesticides have extensively been used in agricultural production in Sri Lanka to control pests and diseases and hence to get maximum yield (Sutharsan *et al.,* 2014). However, indiscriminate use of pesticides leads to the accumulation of pesticide residues in the crop produced, and causes numerous health and environmental impacts (Lakshani *et al.,* 2017).

Under the control of pesticides act no. 33 of 1980, provisions has been set out to declare safe limits for pesticide residues in local consumptions of fresh fruits and vegetables. In order to complement national food safety assurance, 221 pesticides tolerance limits (maximum residue limits, MRLS) on 39 crop/food categories for 65 active ingredients (Anonymous, 2016) were finalized for the Government gazette extraordinary notification. Use of pesticides in dissentient manner has several drawbacks such as health risks, residues remains may pollute the environment including water bodies and may disrupt the ecological balance of pest control by natural enemies and may lead to secondary pest upsets.

In the Batticaloa district it was suspected that farmers are using cocktail mixtures of pesticides in vegetable farming. It was also commented highly that the farmers are not rely on the recommendation of the Department of Agriculture while using pesticides (Sutharsan *et al*., 2014). Sheikh *et al*., (2013) showed that spray of pesticides on vegetable crops was a very common practice which not only kills pests but also remain in outside or get inside the vegetables through minute pores thereby become its component (i.e. pesticide residues) that become a great health hazard after consumption. Pesticides are potentially toxic to humans and can have both acute and chronic health effects, depending on the quantity and ways in which the person is exposed to pesticides (WHO, 2018).

Thus, the present study focused on analyzing some selected pesticide residues in okra according to the AOAC official method 2007.01 and by using Gas *Chromatography*-Triple *Quardrupole* Mass *Spectrometry* (GC-MS-MS) detection in okra. Prior to pesticide residue analysis, information on types of pesticides that are being used frequently by farmers were collected in order to determine common practices used by farmers during pesticides application and to identify the common media used by farmers to get information about pesticides.

Materials and Methods

Questionnaire Survey

A questionnaire survey was conducted inManmunai south and Eruvil pattu DS Division and Poratheevu pattu DS Division in Batticaloa districtduring July – August 2018 by using 40 farmers who engaged in okra cultivation. Questionnaire was designed in both English and Tamil languages. This questionnaire survey was carried out by interviewing individual farmers in their own cultivation field in the presence of an

Agriculture Instructor. The questionnaire was arranged to collect relevant information *viz*., socio-economic background, safety measures while applying pesticides and the types of frequently used pesticides, farmer's common practices during application of pesticides, the common media used by farmers to get information about pesticides and their knowledge regarding pesticide usage. The data obtained from the questionnaire survey were analyzed by using *SPSS* 19.0 statistical software.

Pesticide Residue Analysis in Vegetables

Dimethoate, Carbofuran, Diazinon, Chlorothalonil, Metalaxyl, Malathion, Fenthion, Chloropyrifos, Isoprothiolane, Thiamethoxam, Flutolanil, Profenofos, Oxadixyl, Bifenthrin, Phosalone, Pyraclostrobin, Difenoconazole I, Difenoconazole II, Dimethomorph 1 and *Dimethomorph2* were selected for the study due to their extensive usage, toxicological effects and also based on the availablility of analytical facilities. Among the selected pesticides *Dimethoate* and *Fenthion*, are banned and *Carbofuran, Chloropyrifos* and *Diazinon* are restricted in Sri Lanka.

Sample collection was done by using 20 farmers at their farm gate from Manmunai South and Eruvil Pattu DS Division and Poratheevu Pattu DS Division in Batticaloa district. They were selected based on the production quantity of vegetables where Manmunai south and Eruvil pattu DS Division is the major vegetable cultivating DS Division in Batticaloa district. And the markets were selected based on the population/ consumer availability in each area. Here the selected market places were Batticaloa (Manmunai North DS division), Vellavely (Poratheevu Pattu DS Division), Arayampathy (Manmunai Pattu DS Division), Kaluwanchikudy and Kaluthavalai (Manmunai south and Eruvil pattu DS Division), Eravur (Eravur Town DS Division), Chenkalady (Eravur Pttu DS Division), Oddamavadi (Koralai pattu west DS Division) and Valaichchenai (Koralai Pattu DS Division). 1 kg of okra farmer field samples was collected at their farm gate and 1kg of okra market samples were collected by using 9 market places in Batticaloa district at the time of they are ready for selling to consumers. Then collected samples were taken for pesticide residue analysis within 24 hours after collection. The sample analysis was done in the food laboratory of the Government Analyst's Department of Sri Lanka.

The samples were extracted according to the AOAC official method 2007.01. A kilogram of samples was homogenized by using a blender and 15 g of it was transferred into 50 ml centrifuge tube. Then 15 ml of acetic acid in acetonitrile was added into it for sample extraction. Then the sample drying and buffering was done by adding a packet ofAOAC salt (*QuEChERS)* containing 6 g of anhydrous *magnesium sulfate* ($MgSO_4$) and 1.5 g of *sodium acetate* (NaOAc). Then for the phase separation, the sample was centrifuged at 400 rpm for 5 minutes. Dispersive- solid- phase extraction (SPE*) cleanup* was done by transferring 1 ml of supernatant into Dispersive SPE tube (2 ml) which contained 150 mg of $MgSO_4$, 50mg of primary secondary amine (PSA) and 50 mg of C_{18}. The resultant mixture was *centrifuged* at 13000 rpm for 2 minutes, then immediately 250 µl of it was transferred into glass auto-sampling vials (1 ml). Then 25 µl of 500 ng/ml *Triphenyl Phosphate* (TPP) internal standard and 15 µl

D-*sorbitol* analyte protectant was added and the vial was capped and transferred for Gas *Chromatography* Triple *Quardrupole* Mass *Spectrometry* analysis.

The presence of pesticide was confirmed based on the retention time (RT) and analyzing the mass spectrum. Recovery studies were performed at a range of 0.01mg/kg to 0.1mg/kg and recoveries were obtained within the range of 70- 120%, with an associated repeatability $RSD_r \leq 20\%$ (Relative Standard Deviation RSD) for all analytes. The recoveries were obtained with a linearity criteria of $R^2 \geq 0.98$- 0.99 and the 0.01 mg/kg was used as the Limit of Quantification (LOQ). Acceptable mean recoveries should be within the range of 70- 120% with an associated repeatability $RSD_r \leq 20\%$ for all analytes (SANCO, 2015).Reported residue levels were compared with the EU MRL values. The data from sample analysis were statistically analyzed by using SPSS 19.0 statistical software.

Gas Chromatography- Triple Quardrupole Mass Spectrometry instrument configuration

For analysis, *Agilent* 7890A GC gas *chromatograph* system equipped with *Agilent* 7000 C triple *quardrupole GC/MS* and*Agilent* 7693A automatic liquid sampler was used. Residues were separated through *Agilent J&W HP-5MS* 5% phenyl Methyl Silox; 30m× 250µm, 0.25µmN_2 collision gas flow rate: 1.5 ml/min. carrier gas used was He and He quench gas flow rate: 2.25 ml/min.

Temperature program: Initial temperature 70 °C for 0.06 min followed by 600 °C/min to 310 °C (10 min hold) and then 20 °C/min to 150 °C (until the end of the analysis). Oven temperature program: 60 °C for 1.0 min; then 40 °C/min to 120 °C; then 5 °C/min to 300 °C: then 50 °C/min to 280 °C (1.5 min hold).

Results and Discussions

Questionnaire survey

According to the data obtained in the present study, most of the farmers did not have formal education. Only 22.5% studied up to G. C. E. Ordinary Level and 20% of farmers studied up to G. C. E. Advanced Level. Among the interviewed farmers, majority of them (45%) represented the age group between 31 to 50 and 17.5% were above 50 and others were below 31. Majority of the farmers were engaged in farming as their main occupation. Annual income varied from Rs.80000 to Rs.400000 and the majority (65%) represented the income level between Rs.100000 to Rs.200000. 47.5% of them have below 10 years of experience and 32.5% of them have 10 to 20 years of experience and remaining have more than 20 years of experience in farming.

During cultivation there was 100% pest attack in their fields and all the farmers were following chemical control measures. Majority of them (90%) used chemical pesticides as soon as they observed pests in the field. The study of Nagenthirarajah and Thiruchelvam (2008) also reported that almost all the farmers in Sri Lanka depended on chemical pesticides to control pests in their cultivation. Sutharsan *et al.*, (2014) also revealed that there is a high frequency of chemical pesticide usage in Manmunai south

and Eruvil Pattu DS Division.Further the survey stated that majority of the farmers obtained recommendation from sellers rather than getting through proper channels. The findings of the present par with findings of Kumarapeli (2006) which suggested that farmers ignore technical recommendations and they apply pesticides based on their own experience. 90% of the farmers in study area use high dosages of pesticide than the recommendation to dilute with water (Sutharsan *et al*., 2014).

Study shows that few okra farmers were maintained the proper pre harvesting intervals where majority ignored it. Chandra *et al*, (2010) recorded that some of the pesticides used in the country by farmers do not maintain proper pre-harvest interval after last application. Agnihotri, (1999) stated that repeated application of wide range of pesticides may lead to undesirable residues on crop produce. During the pre-harvest interval, the pesticide may be broken down in the plant, or on its surface. Sun, rain and warm temperatures may affect on this breaking down process of pesticide in plant or on its surface.

The survey also pointed out thatcocktailed pesticides were used by 75% of farmers in the study area. According to Sutharsan *et al.*, 2014 majority of (91%) the farmers applied cocktailed pesticides. It is obvious that indiscriminate application of pesticides and use of incorrect pesticide mixtures can cause many problems to the human health (Kumarapeli, 2006; Lakshani *et al.,* 2017). Although the majority (70%) of the farmers well aware about safety measures while applying insecticides *viz*., wind direction and safety clothes, 30% of them ignorant to the safety measures and imprecisely handling the toxic insecticides.

The survey also revealed that the restricted pesticide, *Diazinon* in Sri Lanka (Anonymous, 2016) was used by 15% of the farmers, which is totally an unethical in cultivation. Their frequent pesticides were *Acetamprid, Diazinon, Abamectin, Profenofos* and *Etofenporx,* It was observed from the survey that most of the pesticides used by the farmers are not recommended for okra, which clearly showed that the farmers had lack of knowledge about the relevant pest and on which the pesticides have been recommended. Khan *et al*., (2006) reported that the 90% of vegetable growers were found with lack of knowledge regarding the recommended doses, pre harvest intervals and the harmful effects of these chemicals on human health.

Pesticide residues in okra samples

The *GC/MS/MS* analysis showed that there were negligible amount or no pesticide residues of tested pesticides *viz*., *Dimethoate, Carbofuran, Diazinon, Chlorothalonil, Metalaxyl, Malathion, Fenthion, Chloropyrifos, Isoprothiolane, Thiamethoxam, Flutolanil, Profenofos, Oxadixyl, Bifenthrin, Phosalone, Pyraclostrobin, Difenoconazole I, Difenoconazole II, Dimethomorph 1* and *Dimethomorph2* were found in okra farmer field samples collected at Manmunai south and Eruvil pattu DS division and Poratheevu Pattu DS division and also in 9 market samples in Batticaloa district. From them *Chlorothalonil, Carbofuran, Malathion, Thiamethoxam, Phosalone and Pyraclostrobin* were not in recovery study for okra matrix.

Table 1: Levels of pesticide residues in okra samples.

Pesticide	EU MRL (in mg/kg)	Range of residue levels in 20 farmer field samples (in µg/kg)	Range of residue levels in 10 market samples (in µg/kg)
Dimethoate	0.01	0.00-0.48	0.01-0.48
Diazinon	0.01	0.00	0.00
Metalaxyl	0.01	0.00-0.20	0.00-0.50
Fenthion	0.01	0.00	0.00
Chloropyrifos	0.01	0.00	0.00
Isoprothiolane	0.01	0.00	0.00-0.04
Flutolanil	0.01	0.00	0.00
Profenofos	0.01	0.00	0.000
Oxadixyl	0.01	0.00	0.00
Bifenthrin	0.01	0.00	0.00
Difenoconazole I	0.01	0.40-0.72	0.4-0.65
Difenoconazole II	0.01	0.30-0.52	0.32-0.064
Dimethomorph 1	0.01	0.20-0.30	0.25-0.36
Dimethomorph2	0.01	0.13-0.21	0.14-0.31

As per the table 1, the analyze results shows that residue levels are in µg/kg where MRL values are in mg/kg. So the recovered residue levels were negligible when compared with Maximum Residue Level. In food, pesticides may occur at very low concentrations, usually at ppm levels. There are so many analytical methods used to detect pesticide residues and all contained certain basic steps that include sampling, sample preparation, extraction, clean up and identification (Lesueur *et al*., 2008). While food processing some of the pesticide residues get destroyed. Keikotlhaile *et* al., (2010) reported that reduction of residue levels was indicated by blanching, boiling, canning, frying, juicing, peeling and washing of fruits and vegetables. Therefore this negligible amount of residue may not be harmful as it can be destroyed while food processing.

Conclusion

Most of the farmers in Manmunai South, Eruvil pattu and Kalawanchikudy D. S. Division and Porathivu pattu DS division in Batticaloa district have not rely on the recommendations given by the Department of Agriculture, Sri Lanka and in the label of respective pesticides while applying them in cultivation.

As the study only certain pesticides *viz*., *Dimethoate, Carbofuran, Diazinon, Chlorothalonil, Metalaxyl, Malathion, Fenthion, Chloropyrifos, Isoprothiolane, Thiamethoxam, Flutolanil, Profenofos, Oxadixyl, Bifenthrin, Phosalone, Pyraclostrobin, Difenoconazole I, Difenoconazole II, Dimethomorph 1* and *Dimethomorph2* were analyzed and it is further recommended to analyze other

pesticides namely, *Acetamprid, Diazinon, Abamectin,* and *Etofenoprox*, which are highly available in the Batticaloa district.The study stated that the okra is not 100% free from pesticide residues that were subjected to the present study and some of other pesticides are needed to be tested.

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ALTERNATIVE OPTIONS FOR SYNTHETIC FUNGICIDE FOR TREATING SEEDS OF CHILLI (*Capsicum annuum* L.)

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Abstract

Seed borne pathogens can cause ample damage to seeds and seedlings of chilli. Currently, farmers treat chilli seeds with synthetic fungicides to control fungal diseases. Therefore, developing alternative fungicidal approaches is crucial to avoid the detrimental effects of synthetic fungicides. Therefore, the present investigation was undertaken to evaluate different seed treatment methods for chilli cv. PC-1. The experiments were laid out in completely randomized design. Four treatments namely, 5% clorox for 40 min soaking period, 20% bougainvillea leaf extract for 24 h soaking period), captan synthetic fungicide (4 g/kg of seeds) and also water as control treatment were replicated five times in both laboratory and potexperiments. Data were recorded for seed germination percentage and number of days taken to germinate 50% of seeds during petri dish method of seed germination. Total number of viable microorganisms present in seeds was also counted using serial dilution plate technique. Disease incidence percentage, leaf area, seedling length and seedling vigour index were measured during the pot experiment. Data were statistically analysed at 5% significant level. Among the seed treatments tested, clorox was found to be as significantly-efficient as captan in improving germination percentage. There were no significant differences between clorox and bougainvillea leaf extract in germination percentage and number of days taken to germinate 50% of seeds. Significantly least total count of viable microorganisms was recorded in both captan and clorox treated seeds. Results of pot experiment revealed that seedling characters *viz.* seedling length and leaf area were significantly greatest in captan treatment followed by clorox. Seedling vigour index and disease incidence percentage were significantly highest in both captan and clorox treatments. However, bougainvillea leaf extract seemed to be less effective for seed treatment of chilli. Clorox has proved to be a good seed treatment agent in controlling seed borne fungal pathogens as equally-capable as captan fungicide. Therefore, clorox could be recommended as seed treatment agent for chilli instead of using captan fungicide to control seed borne fungal diseases.

Keywords: Bougainvillea leaf extract, Captan, Chilli, Clorox, Seed treatment

Introduction

Chilli (*Capsicum annuum* L.) is considered as one of the commercially grown universal spice crops. It has become an essential ingredient in Sri Lankan meal. In case of Sri Lanka in 2015 production was 62,866 Mt and extent was 13,029 ha. Average annual production is 30,000 Mt (Department of Agriculture, Sri Lanka, 2015). Per capita

consumption of chilli in the form of dry chilli is estimated 2.84 kg per annum and the national annual requirement of dry chilli is around 57,400 Mt. Chilli is cultivated in large scale in the dry zone especially in north central province and the intermediate zone. At present, major chilli growing districts are Anuradhapura, Moneragala, Ampara, Puttlam, Vavuniya, Kurunegala and Hambantota.Chilli suffers from many diseases caused by fungi, bacteria, viruses, nematodes and also abiotic stresses. Fungal diseases play a vital role in reducing the germination of chilli. Among the fungal diseases; damping off, anthracnose, powdery mildew and leaf spots are the most prevalent ones. The fungi *Fusarium oxysporum*, *Sclerotium rolfsii* and *Rhizoctonia solani* are soil inhibiting pathogens with wide host range. Anthracnose is a seed borne disease caused by *Colletotrichum capsici*, limiting the profitable cultivation (Choudhary *et al*., 2013).

The effect of certain plant extracts on the management of some diseases of chilli such as die back, fruit rot, anthracnose were identified. At present synthetic fungicides are commonly being used to control these diseases. But the practice is highly risk for public health as the green fruit is eaten with or without cooking. These toxic chemicals directly enter into human tissue, get deposited and at critical concentration cause serious health disorder. This realization emphasizes the importance of finding materials and products, which are safe for human health as well as environment. Therefore, use of plant and natural products may guarantee for safe and healthy production of chilli. The phytochemicals present in bougainvillea leaf extracts are responsible for antimicrobial activity of the leaf extract (Umamaheswari *et al*., 2008).

Seed treatment is a process of treating seeds by any physical, chemical, biological or other agents to destroy harmful seed – borne organisms or to protect the seeds against infection. It is done to prevent germination failure and seedling infection, to destroy external and internal seed borne pathogens and to develop protective zone around the seed in the soil which protects the germinating seeds and seedlings from the attack of certain soil borne pathogens (Alam *et al*., 2014). To increase the production of chilli qualitatively and quantitatively, farmer requires healthy and quality seeds with high percentage of germination and purity. Another adverse effect of seed borne pathogen is it will contaminate the areas which were disease free previously. So it necessitates the eradication of seed borne inoculums through various seed treatments. Hence, the present investigation was undertaken to evaluate the effects of seed treatments with chemicals and botanicals on the prevalence of major seed borne fungi, germination percentage, seedling health and vigour of chilli. The objectives of the present study were to identify alternative options for synthetic fungicidal seed treatment to remove the seed borne fungal pathogens of chilli and determine the effects of seed treatments on seedling performance of chilli plants.

Materials and Methods

The experiments were conducted at the microbiology laboratory and the plant house of the Department of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri

Lanka to evaluate different seed treatments for chilli. PC-1 variety was used for this study as it is the most cultivated chilli variety in Batticaloa district.Bougainvillea leaf aqueous extract, clorox (commercial bleach solution), captan fungicide and water were used as seed treatment agents in the present study. Preliminary experiments were conducted to determine the best concentration and soaking period of bougainvillea plant leaf extract and clorox solution.

Evaluation of different seed treatments in laboratory experiment

Chilli seeds were undergone the following four seed treatments and each treatment was replicated five times. Each replicate had 20 seeds in a petri dish.

Treatment 1 - 5% Clorox solution for 40 min soaking period

Treatment 2 - 20% Bougainvillea leaf extract for 24 h soaking period

Treatment 3 - Captan (4 g/kg of seeds)

Treatment 4 - Water (Control treatment)

Captan treatment was done according to the recommendation of the Department of Agriculture, Sri Lanka. Germination percentage of the treated seeds was determined by petri dish method. The treated seeds were placed on sterilized filter paper kept inside a sterilized petri dish and incubated at the room temperature till germination of seeds. Data collected include number of days taken to germinate 50% of seeds and the germination percentage after 14 days. One gram of seeds from each treatment was taken for serial dilution plate technique to count the total number of viable microorganisms as colony forming unit (CFU) present in the seeds.

Evaluation of different seed treatments in pot experiment

This experiment was conducted using plastic pots having the height and diameter of 25 cm and 30 cm respectively. The pots were filled with top soil thoroughly mixed with compost. The same four seed treatments were tested for their efficacy in the pot experiment as well. Four seeds were directly sown in each pot after the respective seed treatment and the pots were kept in the plant house. The experiment was laid out in the completely randomized design with five replications. The following parameters were measured at transplanting stage:

a) Disease incidence
   Damping off and wilting are most common diseases in seedling which are in transplanting stage. Number of seedlings suffered by the diseases was recorded.

b) Seedling length
   The length of the chilli seedlings was measured at transplanting stage. Two plants were randomly selected from each replicate for the measurement of seedling length.

c) Leaf area
Two plants were randomly selected from each replicate of the treatments. Chilli seedlings were uprooted from the pots and the leaves were cut from the base of the petiole. The total leaf area of each chilli seedling was measured by a leaf area meter (Model: LI-3100C).

d) Seedling vigour index
It was calculated by the formula as suggested by Abdul Baki and Anderson (1973) and expressed in whole number.
Seedling vigour index = Germination % x Mean seedling length (cm)

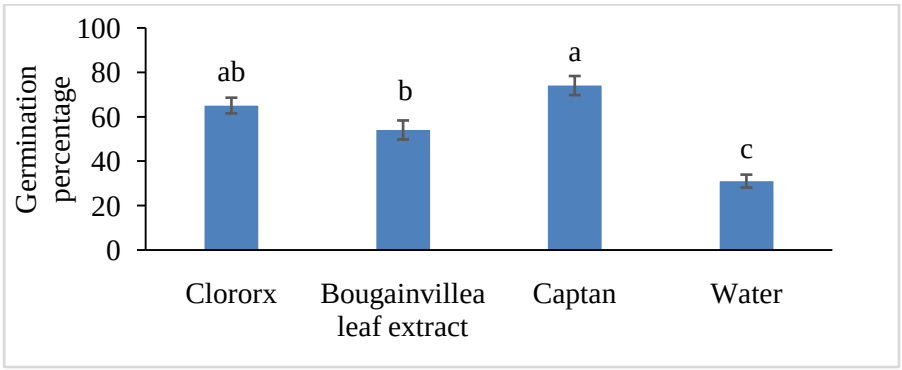
Significance of treatment effects on the measured variables were determined by analysis of variance using SAS 9.1 software. Treatment means were compared using Duncan Multiple Range Test at p=0.05.

Results and Discussion

Evaluation of different seed treatments in laboratory experiment

1. Germination percentage of chilli seeds

It was observed that germination percentage of chilli seeds was significantly ($p<0.05$) influenced by the treatments (Figure 01). Captan and clorox treatments showed highest germination percentages without significant difference between them. The lowest germination was recorded in untreated (water) seeds because of presence of seed borne microflora.



Bars indicate the mean values of five replicates.
Mean values with similar letter are not significant at p=0.05.

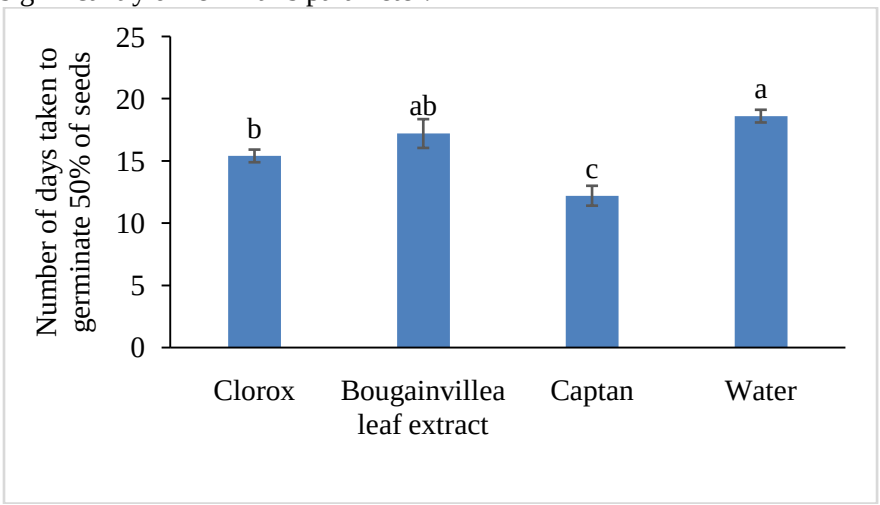
Figure 1: Germination percentage of chilli seeds under different treatments

This study might reflect the effect of seed borne microbes on germination of chilli seeds. Among the treatments, captan and clorox were most effective which improved germination of chilli seeds by minimizing infection of the pathogens. This was in confirmation with the findings of Hedge (1998) reporting that seed treatment of chilli with captan and thiram reduced the seedling damping off to maximum extent and thus

can reduce the secondary spread of the inoculum. In the present study, clorox increased the germination of seeds as significantly-similar as captan. Clorox or sodium hypochlorite contains hypochlorite ion ($^{-}$OCl), which acts as oxidizing agent and kill the microbes (Komahan and Prasannath, 2018).

2. Number of days taken to germinate 50% of seeds

There were significant differences ($p<0.05$) among treatments (Figure 2). Captan took least number of days (12 days) to complete the germination of 50% of seeds. It was followed by clorox and bougainvillea leaf extract, however, these two did not significantly differ in this parameter.



Bars indicate the mean values of five replicates.
Mean values with similar letter are not significant at p=0.05.

Figure 2: Number of days taken to germinate 50% of chilli seeds under different treatments

Kadam *et al*. (2008) reported that long soaking duration in plant extract effective in controlling the growth of the entire surface borne seed microflora. The leaves of bougainvillea are reported to have antimicrobial activity (Edwin *et al*., 2007). *In vitro* antibacterial activity of *Bougainvillea spectabilis* leaves extracts has been reported by Umamaheswari *et al*. (2008). On the other hand, water consumed longest time period to accomplish the germination of 50% seeds. Water does not contain any components to kill the microbes.

3. Total number of viable microorganisms

The results revealed that there was a significant difference ($p<0.05$) between treatments in the prevalence of microorganisms (Table 1). Among treatments, there was no significant difference between clorox and captan treatments which registered significantly the lowest CFU value. On the other hand, the highest CFU value was shown by control (water) treatment. In case of clorox or sodium hypochlorite, its mechanisms of germicidal activity include inhibition of enzyme activity essential for

the growth, damage to the membrane and DNA, and perhaps an injury to membrane transport capacity (Fukuzaki, 2006).

Table 1: Prevalence of microorganisms in chilli seeds under different treatments

Treatment	CFU / g of seeds
T1	1.52×10^9 c
T2	3.26×10^9 b
T3	1.18×10^9 c
T4	1.02×10^{10} a

Mean values with similar letter are not significant at p=0.05

Evaluation of different seed treatments in pot experiment

1. Disease incidence of chilli seedlings under different treatments

Table 2 shows that the disease incidence of chilli seedlings was significantly ($p<0.05$) influenced by the treatments. Results indicated that the disease incidence was significantly reduced by clorox as equally-capable as captan fungicide. Commonly observed disease was pre-emergence damping off. Seed borne fungi are responsible for poor vigour and low seedling emergence in the nursey. The seedling emergence in seed sample could have been low due to proliferation of pathogenic fungal species on germinating seedlings and resulting in seed and seedling death (Singh and Maheshwari, 2002). Better results from the bougainvillea leaf extract could have been achieved if leaves were extracted using organic solvents (Krishna *et al*., 1997).

2. Seedling length of chilli seedlings under different treatments

Table 2 shows that there was a significant difference ($p<0.05$) between treatments in the seedling length. Significantly highest shoot length was noticed in captan treated seeds as compared with other treatments. Captan was followed by clorox and bougainvillea leaf extract, however, the last two did not significantly differ in seedling length. Meanwhile, water treatment gave the lowest seedling length. Similar findings were noticed by Mathur *et al.* (1975) who reported that sowing seeds infected by fungi, showed shoots appearing highly blighted and shoots length was greatly affected.

3. Leaf area of chilli seedlings under different treatments

Table 2 shows that highest leaf area was given by captan treatment as it promoted the growth of seedlings by preventing them from pathogenic infections. On the other hand, the lowest leaf area was recorded by water treatment. Clorox and bougainvillea leaf extract were not significantly different in leaf area of seedlings.

4. Seedling vigour index of chilli seedlingsunder different treatments

Clorox and captan significantly ($p<0.05$) enhanced the seedling vigour index compared to the other treatments (Table 2). Both treatments were equally efficient in improving seedling vigour. There was no significant difference between bougainvillea leaf extract and water in seedling vigour index. Common and dominant seed borne fungi were

found to be inhibitory for seed germination and caused great loss in seedling vigour (Pathania and Chandel, 2004; Telang, 2010).

Table 2: Effects of different seed treatments on disease incidence, seedling length, leaf area and seedling vigour index of chilli seedlings

Treatment	Disease Incidence (%)	Seedling Length (cm)	Leaf Area (cm^2)	Seedling Vigour Index
T1	16.3 b	3.3 b	1.22 b	369.2 a
T2	28.8 a	3.7 b	0.88 b	207.2 b
T3	13.8 b	6.9 a	2.13 a	458.8 a
T4	30.0 a	2.3 c	0.04 c	129.6 b

Mean values with similar letter are not significant at p=0.05.

Conclusion

The results of the study revealed that seed treatment with clorox which is generally regarded as safe was found to be equally efficient in comparison to Captan fungicide. Hence, clorox would be helpful in preventing germination failure and producing healthy seedling with good vigour. However, bougainvillea leaf extract did not exhibit a significant effect on seed treatment of chilli. Therefore, it could be concluded that clorox would be an alternative option for synthetic fungicides as a seed treatment agent for chilli.

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BIO EFFICACY OF PRE-PLANT HERBICIDE:*TIAFENACIL 50g/L*ME

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Abstract

Glyphosate and Glufosinate ammonium are the two non-selective herbicides recommended by the Department of Agriculture (DOA), Sri Lanka for control weeds in lands. Government imposed banned glyphosate and restricted glufosinate ammonium in recent past due to many reasons such as toxicity profile of pesticides, chronic kidney disease (CKDU) developed in North Central region of Sri Lanka, new government regulations, etc. Recently, Tiafenacil 50 g/l ME has been granted approval for testing in Paddy and Non crop land to address the issue of weed management as a non-selective weedicide. A field experiment was conducted adopting RCB Design with three replicates during the month of July 2018 at four different locations namely Manapaha, Mukalanyaya, Maha Illuppallama and Seetha Eliya, Sri Lanka in order to evaluate bio efficacy of pre-plant herbicide; Tiafenacil 50 g/l ME and to find out the most suitable dosage to be used in paddy and non-crop lands. All data were analyzed using SAS Statistical software. Two dosage of 3.125 l/ha (T3) and 3.75 l/ha (T4) control weeds in -low land and high land satisfactorily. However, the rates could be reduced to 2. 5 l/ ha (T2) under lowland conditions (paddy) and increased under high land (Non crop) condition 5l/ ha (T6). Under highland conditions, increasing the rate from 3.75 l/ha (T4) to 5 l/ha (T6), WCE will increase by 9%.Therefore, Tiafenacil 5% ME formulation at 187.5 - 250g a.i. /ha (3750-5000 ml/ ha) could be selected to control weeds in highlands whereas Tiafenacil 5% ME formulation at 125 - 156.25 g a.i./ ha (2500 - 3125ml/ ha) could be effectively used to control weeds in lowlands.

Keywords: Bio efficacy, Quadrate, Pre-plant herbicide, Tiafenacil 50% ME, Herbicide testing

Introduction

Glyphosate and Paraquat like total weed killers have been banned in Sri Lanka in the past. Since then, most of the agricultural sectors; especially paddy, tea and other field crop cultivations had to find solutions to control weeds. However, most of the methods used currently are highly labor required, high time consuming and highly expensive. Therefore, to address the issue a total weed killer is highly required at the moment. Tiafenacil 5% ME is a broad spectrum, non-selective weed killer with newly invented mode of action. (Inhibiting PPO (Protoporphyrinogen IX oxidase) in Plants) This study

was conducted to evaluate bio efficacy of Tiafenacil 50 g/l ME in Paddy and Non Crop land and to find out the most suitable dosage to be used in Sri Lanka in paddy and non-crop lands.

Materials and Methods

Field experiments were conducted at 4 locations in Sri Lanka (Table 1) adopting RCB Design with three replicates per each treatment in July 2018.

Table 1: Details of experimental site with specification

Location	Location Details	Crop/ Specification
1	Kurunegala, Manapaha	Paddy field
2	Kurunegala, Mukalanyaya	Non crop/ Bare land
3	Maha Illuppallama, FCRDI	Paddy field
4	Seetha Eliya, ARS	Non crop/ Bare land

Two experimental sites in Kurunegala district were selected to evaluate both lowland (experimental site 1 - Manapaha) and highland (experimental site 2 - Mukalanyaya) field operations. Each experimental site was demarcated into 5 plots ($T_1 – T_5$) size 6' X 3'. Lowland from Field Crop Research and Development Institute, Maha Illuppallama was selected and conducted the same as Kurunegala. Highland from ARS, Seeta Eliya was selected and was demarcated into 6 plots ($T_1 – T_6$) due to high canopy cover in weed flora and treated with six types as elaborated in Table 2.

Table 2: Treatments, and application rate of Tiafenacil 5% ME

Treatment	Formulation	Application Rate	
		(g a.i. / ha)	l/ ha
T_1	Tiafenacil 5% ME	93.75	1.875
T_2	Tiafenacil 5% ME	125	2.500
T_3	Tiafenacil 5% ME	156.25	3.125
T_4	Tiafenacil 5% ME	187.5	3.750
T_5	Un treated	UN	
T_6	Tiafenacil 5% ME	250*	*5.000

**Location number 4, Seetha Eliya Only*

Weed Sample Collection and Analysis

Weed flora in each experimental site was noted prior application of the chemical. Using a 36cmx36cm (0.1296 m^2) quadrate, weed samples were collected from 3 places of each plot (R_1, R_2 and R_3). Dry weight of plants was measured after separation into 3 categories (grasses, sedges and broad leaves). The same procedure was carried out on 10^{th} day after application (DAA). Weed controlling Efficiency (WCE) for each treatment was calculated by the formulae: WCE% = [*(Weed Dry Weight of Non*

weeded Control – Weed Dry weight of treatment Interested)/ Weed Dry Weight of Non weeded Control x 100]. Data were analyzed using SAS Statistical software.

Results and Discussion

At location No.1, Paspalum vaginatum, Eleusine indica and Ischaemum rugosum were prominent adopting over 50% of the total weed population while Melochia corchorifolia, Ipomoea littoralis and Commelina diffusa were prominent in location No. 2. Location No. 3 was dominated by Paspalum vaginatum, Fimbristylis dichotoma and Ischaemum rugosum whereas Arundinella villosa and Chrysopogon zeylanicus were found dominant in Location No. 4. According to the data, after 10 days of chemical application, Paspalum disticum, Panicum repens, Commelina bengalensis were found remaining in above sites collectively. However, the remaining weed population was found as minute as 2% - 5% from the initial weed population. From above remaining weeds, Paspalum disticum accounted for the highest population (60%) followed by Panicum repens (25%) and Commelina bengalensis (12%).

Weed count, Weed dry weight and Weed Control Efficiency (WCE) of different treatments 10 days after treatment at location number 1 is listed in Table 3. Here broad leaf weeds and grass weed population were significantly higher than sedges. This may be due to the soil and management practices of the site.

Table 3: Weed count, weed dry weight and weed control efficiency (WCE) of different treatments 10 days after treatment at Manapaha, Kurunegala (location no: 01)

Treatment (l/ha)	Weed count/m^2			Dry weight g/m^2			Total weed bio mass (g/m^2)	WCE %
	G	BL	S	G	BL	S		
1.875	29.47 b	17.35 bc	1.92 b	60.17 b	12.2 b	2.50 b	74.87 b	70.20
2.500	13.45 b	25.30 b	0.5 b	24.5 b	19.5 b	0.5 b	44.00 b	82.49
3.125	8.83 b	0.50 c	0.5 b	16.7 b	0.5 b	0.5 b	26.00 b	93.35
3.750	11.47 b	1.92 bc	0.5 b	18.22 b	0.5 b	0.5 b	18.22 b	92.75
UN	77.57 a	85.55 a	30.30 a	167.62 a	70.02 a	13.6 a	251.25 a	**

***Means with the same letter within a column are not significantly different (ά=0.05)*

After 10 days of the chemical application, all chemical treated plots were significantly low in total weed bio mass comparatively to no weeding treatment. However, out of 4 chemical treatments, T4 was recorded with the lowest total weed bio mass.Weed count, Weed dry weight and Weed Control Efficiency (WCE) of different treatments 10 days after treatment at location number 2 is listed in Table 04. In this location sedge weeds were not found may be due to soil condition of the location. After 10 days of the chemical application, all chemical treated plots were significantly low in total weed bio mass comparatively to no weeding treatment. However, out of 4 chemical treatments, T4 was recorded with the lowest total weed bio mass.

Table 4: Weed count, weed dry weight and weed control efficacy (WCE) of different treatments 10 days after treatment at Mukalanyaya, Kurunegala, (Location No: 02)

Treatment (l/ha)	Weed count/m^2			Dry weight g/m^2			Total weed bio mass (g/m^2)	WCE %
	G	BL	S	G	BL	S		
1.875	46.3 b	33.43 b	0.5 b	46.56 b	44.13 ab	0.5 b	90.70 b	71.76
2.500	25.73 b	2.56 bc	0.5 b	35.40 b	3.20 b	0.5 b	38.60 b	87.98
3.125	20.56 bc	10.26 bc	0.5 b	18.83 b	9.00 b	0.5 b	27.83 b	91.33
3.750	7.70 c	0.05 c	0.5 b	12.63 b	0.00 b	0.5 b	12.63 b	96.07
UN	179.96 a	225.63 a	16.73 a	125.06 a	165.8 a	30.26 a	321.13 a	**

***Means with the same letter within a column are not significantly different (á=0.05)*

Weed count, Weed dry weight and Weed Control Efficiency (WCE) of different treatments 10 days after treatment at location number 3 is listed in Table 5.

Table 5. Weed count, weed dry weight and weed control efficacy (WCE) of different treatments 10 days after treatment at Maha illuppallama (location no: 03)

Treatment (l/ha)	Weed count/m2		Dry weight g/m2		Total weed bio mass (g/m2)	WCE %
	G	S	G	S		
1.875	353.65 a	63.01 a	216.30 ab	35.23 b	251.54 b	38.66
2.500	83.59 b	16.71 ab	63.14 a	23.14 b	86.29 c	78.96
3.125	68.15 b	6.43 b	64.04 a	23.53 b	87.57 c	78.65
3.750	77.16 b	20.57 ab	62.37 a	19.93 b	82.30 c	79.93
UN	378.08 a	54.01 ab	325.74 a	84.36 a	410.10 a	**

***Means with the same letter within a column are not significantly different (á=0.05)*

In this location no broad leaf weeds were found at the location. After 10 days of the chemical application, all chemical treated plots were significantly low in total weed bio mass comparatively to no weeding treatment. However, out of 4 chemical treatments, T4 was recorded with the lowest total weed bio mass whereas T1 recorded the highest amongst the chemical treated plots.Weed count, Weed dry weight and Weed Control Efficiency (WCE) of different treatments 10 days after treatment at location number 4 is listed in Table 6. In this location sedge weeds were significantly low. This condition may occur due to soil condition and the climatic condition of the location which may not favorable for sedges. After 10 days of the chemical application, all chemical treated plots were significantly low in total weed bio mass comparatively to no weeding treatment. However, out of 4 chemical treatments, T6 was recorded with the lowest total weed bio mass whereas T1 recorded the highest amongst the chemical treated plots.

Table 6: Weed count, weed dry weight and weed control efficacy (WCE) 10 days after treatment of different treatments at Seeta eliya (location no: 04)

Treatment (l/ha)	Weed count/m^2			Dry weight g/m^2			Total weed bio mass (g/m2)	WCE %
	G	BL	S	G	BL	S		
1.875	66.9ab	7.7ab	0.5b	197.1b	8.5a	0.5 b	205.6b	76
2.500	82.3abc	5.1ab	0.5b	148.9b	7.2a	0.5 b	156.1b	81
3.125	141.4ab	0.0b	0.5b	132.3b	0.0a	0.5 b	132.3b	84
3.750	77.2bc	10.3ab	18.0b	105.3b	7.8a	5.1 b	118.2b	86
5.000	12.9c	12.9ab	0.0	19.1b	29.9a	0.5 b	49.1b	94
UN	254.6a	69.4a	15.4b	740.7a	78.4b	20.9a	840.1a	

***Means with the same letter within a column are not significantly different (ά=0.05)*

Conclusions

In experimental location 1 and 3 (Paddy/ Low land), 2.5 l/ha (T2), 3.125 l/ ha (T3) and 3.75 l/ ha (T4) showed the better weed control efficacy over 75 % of WCE whereas 1.875 l/ha also showed satisfactory level of weed control at location Manapaha, Kurunegala (Around 70% of WCE). Two dosage of 3.75 l/ha and 5 l/ha (187.5 g a.i. /ha and – 250g a.i. /ha) were highly effective to control weeds in highlands Therefore, Tiafenacil 5% ME formulation at 187.5 - 250g a.i. /ha (3750-5000 ml/ ha) could be selected to control weeds in highlands whereas Tiafenacil 5% ME formulation at 125 - 156.25 g a.i./ ha (2500 - 3125ml/ ha) could be effectively used to control weeds in lowlands. Further, It is noted and recommended 156.25 g a. i./ ha (5000 ml/ ha) for highlands if weed canopy at high stage.

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ISOLATION, IDENTIFICATION AND EVALUATION OF MASS CULTURE MEDIA FOR TRICHODERMA SPP. FROM SRI LANKA

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Abstract

Trichoderma spp. are a group of free living microorganisms commonly found in soil and root zones of plants. Some members of this species are widely and effectively used as bio control agents against diverse plant pathogens. More than 60% of the registered fungi-based bio-fungicides developed and in use today are based on *Trichoderma* spp. Hence, this study was carried out with the objectives of isolation and identification of locally available effective *Trichoderma* spp. and identification of solid state mass culturing media for the identified *Trichoderma* isolate. Soil samples were collected from farmer fields and *Trichoderma* was isolated and purified. Morphological and molecular studies of PCR amplification with ITS1/ITS4 universal primers confirmed the isolated bio control agent as *T. asperellum.* Seven media namely; sorghum grains, sweet sorghum grains, cracked maize grains, rice bran, cow dung, rice straw and dried banana leaves were tested as mass culturing media for identified *T. asperellum* under laboratory conditions during 2018. According to the results, sweet sorghum gave significantly highest conidial yield of $1.02x10^9$cfu/g 17 days after inoculation. Sorghum grains and cracked maize grains secondly showed better results compared with other selected media. Among the media used, sweet sorghum can be used as effective mass culturing media for the isolated *Trichoderma asperellum* mass multiplication.

Keywords: Bio-control agent Mass culture media, *Trichoderma asperellum*

Introduction

Diseases play a major role in reduction of worldwide crop yields and thereby contributing to loss of farmer income. For the period of 2001-2003 nearly 16% yield losses occurred globally due to plant diseases (Popp and Hantos, 2011). Though correct use of fungicides can deliver reduction of disease pressure, there are problems associated with these pesticides. Hence, less harmful natural (bio) products are increasingly preferred substitutes to synthetic pesticides. *Trichoderma* is a widely used

bio control agent, which is known to have effective control on diverse plant pathogens (Kandhelwal *et al*., 2012).

Trichoderma arefree-living fungi commonly found in soil and root ecosystems. They are opportunistic, virulent plant symbionts, as well as being parasites of other fungi (Harman *et al*., 2004). The ability to parasitically antagonize and kill other fungi (mycoparasitism) emphasizes the wide spread nature of *Trichoderma* as a bio control agent around the world (Atanasova *et al*., 2013). Other than the mycoparasitism; spatial and nutrient competition, antibiosis by enzymes and secondary metabolites, and induction of plant defense system are considered as the major bio-control actions of these fungi (Verma *et al*., 2007).

Trichoderma is effective against diverse plant pathogens; *Armillaria, Botrytis, Chondrostereum, Colletotrichum, Dematophora, Diaporthe, Endothia, Fulvia, Fusarium, Fusicladium, Helminthosporium, Macrophomina, Nectria, Phoma, Phytophthora, Plasmopara, Pythium, Rhizoctonia, Rhizopus, Sclerotinia, Sclerotium, Thielaviopsi, Venturia, Verticillium, etc.* (Jegathambigai *et al*., 2009; Wijesinghe *et al*., 2010).Ithas a wide species range; *T. harzianum, T. atroviride, T. longibrachiatum, T. asperellum, T. koningiopsis and T. hamatum* as common(You *et al*., 2016). More than 60% of the registered fungus-based bio-fungicides have been developed based on *Trichoderma* spp. (Verma *et al*., 2007). Solid-state fermentation for mass production of *Trichoderma* is very common. Rice and wheat straw (Tewari and Chandrabanu, 2003), sorghum, millets and ragi (Jayaranjan, 2006), rice, corn bran and wheat bran (Cavalcante *et al*., 2008), dried banana leaves, rice bran, farmyard manure (Thangavelu *et al*., 2003), maize cobs, maize grains, cracked maize grains, sorghum grains, paddy straw, etc. (Kumar *et al*., 2009) have been used as solid state media by various researchers.

The identification of an effective bio control agent and an easy and cheap method of its mass production are important considerations for the widespread adoption and commercial application of such bio-pesticides by farmers. Hence, this study was conducted with the objectives of isolation and identification of locally available *Trichoderma* spp. and identification of solid state mass culturing media for the identified *Trichoderma* spp.

Materials and methods

Isolation of the bio-control agent

Twenty-three soil samples were collected from onion farmer fields of Anuradhapura, Mahailluppallama and Matale districts. *Trichoderma* spp. was isolated from these samples using multiple tube dilution technique on Potato Dextrose Agar (PDA) medium. Inoculated plates were incubated at 28°C for 4-5 days and green color single colonies were selected from mixed colonies and purified by sub culturing. Pure cultures were incubated at 28 °C for 6-7 days and maintained on PDA slants for further use.

Morphological identification

Morphological observations were done for the purified cultures showing green conidia forming fungal bodies. Microscopic observations were carried out by slide culture technique using microscope (Olympus CX 41, Japan).

Confirmation of identity

Luria broth culture was prepared in a 250ml conical flask and 8mm diameter mycelia disk taken from 7 days old actively growing fungal cultures was placed in luria broth. Already identified and characterized *T. asperellum* isolate obtained from Horticulture Research and Development Institute, Gannoruwa, Peradeniya (Rajapakse *et al*., 2016) was taken as the positive sample. Inoculated flasks were incubated in an orbital shaker at 30 rpm for 7 days at 28 $^{\circ}$C temperature. Total genomic DNA was extracted from the mycelia of the 7 day old broth culture using Cetrimide Tetradecyl Trimethyl Ammonium Bromide (CTAB) extraction method described by Rajapakse *et al*. (2016). PCR amplification was done for the samples with the universal primers; ITS - 1(Forward): 5'- TCCGTAGGTGAACCTGCGG-3' and ITS- 4 (Reverse): 5'- TCCTCCGCTTATTGATATGC - 3' (White *et al*., 1990).PCR mix in a total volume of 10µl consisted of 1µl of the template DNA (100ng DNA) with 0.5µl of each primer (10mM), 0.5µl of 10mM dNTP and 0.2µl of *Taq* DNA polymerase (5U/ µl), 2µl of 5x PCR Buffer with loading dye (Promega, USA), 0.8µl of 25mM $Mgcl_2$ and 4.5µl of sterilized distilled water.

The PCR cycle consisted of steps; an initial denaturation of 5 min at 94°C, followed by 35 cycles of 1min at 94°C, 1 min at 50°C, and 1 min at 72°C, with a final extension of 10 min at 72°C followed by termination of the cycle at 4°C. The PCR was carried out in ABS Verity thermal cycler (Applied Bio Systems, USA). Amplified products were analyzed by electrophoresis in 1.0% (wt/vol) agarose gel in 1XTAE buffer stained with ethidium bromide(0.5 µg/ml) , and photographed over a UV transilluminator. A 100bp ladder (Promega, USA) was used as the marker.PCR products of the samples were sequenced (Macrogen, Korea). BLAST (NCBI) was carried out. Similar sequences were compared with the sequence data obtained in this study using Bio Edit (Version 7.2.5.). A phylogenetic tree was developed using MEGA 6 Software.

Mass culturing of Trichoderma

Mass culturing media were selected considering past research findings, local availability, easy access and cost effectiveness. Seven different media; sorghum grains (T1), sweet sorghum grains (T2), cracked maize grains (T3), rice bran (T4), cow dung (T5), rice straw (T6) and dried banana leaves (T7) were tested as *Trichoderma* mass culturing media under laboratory conditions during 2018 at the Field Crops Research and Development Institute, Mahailluppallama. The experiment was conducted in a complete randomized block (CRD) design with three repeats. Maize grains were cracked into pieces using a laboratory grinder. Rice straw and dried banana leaves were cut into 1-2cm small pieces. Then 50g of each dry media (grains, rice bran, cow dung, rice straw and dried banana leaves) were taken and put in 500ml conical flasks. Media were moistened, sterilized at 15 PSI for 20 minutes in an autoclave and cooled to 50-60°C. 2ml of 2 x 10^7 CFU/ml suspension of *Trichoderma* conidia pure culture

suspension was inoculated to each media sample in a laminar flow chamber. Next the media introduced with *Trichoderma* conidia were kept at room temperature for 17 days. 1g of bio-mass with conidia was taken from each cultured media and conidia yield was measured using a heamocytometer after dilution series at 3-4 days intervals starting from 7 days after inoculation.

Results and discussion

Isolation and Identification of Trichoderma

One *Trichoderma* spp. was isolated from all the collected soil samples in different places and named as *Trichoderma* MI isolate. Colour of the isolated fungi mycelium was initially white then yellow and turned to bright green colour within 7-8 days (Figure 1). Conidia formed densely over the center. Conidia shape was globose to subglobose and branching pattern of conidiophores was regular (Figure 2). Colour and conidial shape were identical to known *Trichoderma* cultures.

Figure 1: *Trichoderma* isolate

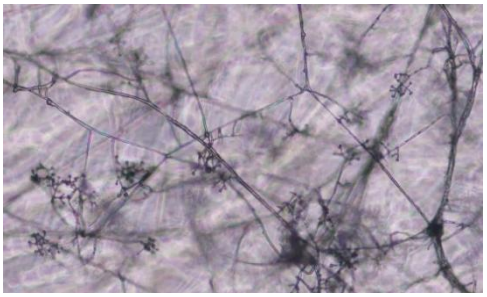


Figure 2: Microscopic observation of *Trichoderma* conidiophores (X40)

Confirmation of identity of the bio control agent

Described morphological characters are not enough to identify the *Trichoderma* isolates since most of the *Trichoderma* isolates have similar morphological characteristics. Hence, there is a need to use molecular tools to overcome the limitations of morphological characterization. Amplification of the DNA region of the *Trichoderma*isolate with ITS1 and ITS4 primers yielded products of approximately 580bp as estimated by agarose gel electrophoresis in both isolated and positive samples (Figure 3).

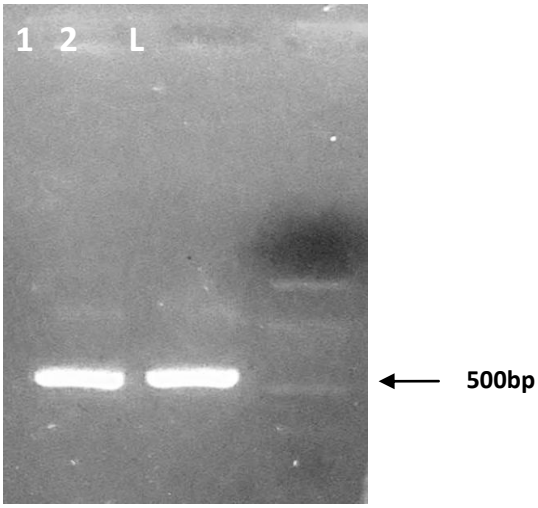
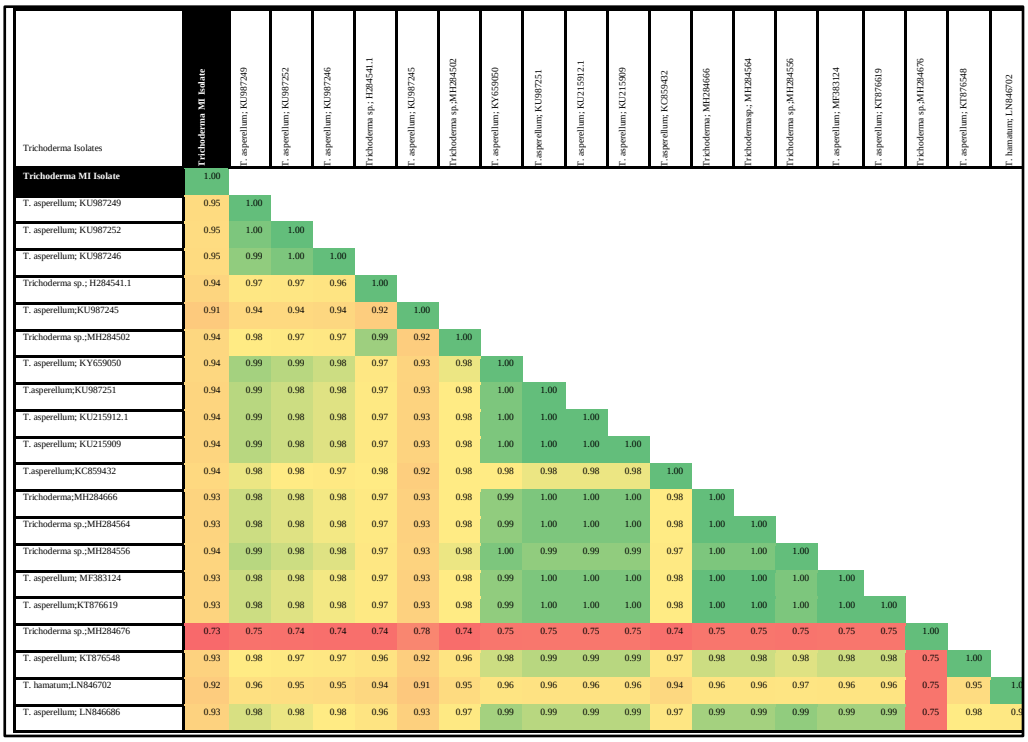


Figure 3: PCR amplification of ITS region form the DNA of *Trichoderma* MI isolate with ITS1 and ITS4 universal primers. Lane L- 100bp ladder; lane 1- Isolated *Trichoderma* MI isolate; lane 2- +*ve* Sample

Through sequencing a 339bp portion was obtained. Sequence analysis showed that the sequence data of the ITS region (ITS1-5.8S) of the *Trichoderma* spp. isolated from the soil of the onion field of the Field Crops Research and Development Institute was matching with 19 sequences available at the NCBI, reported from different countries, more than 90 percent. Comparison of the sequences data of the *Trichoderma* MI Isolate with selected sequence data available at the NCBI showed that *Trichoderma* MI Isolate has 95% nucleotide identity with *T. asperellum* from Morocco and 94% nucleotide identity with *T. asperellum* from China, Egypt, Morocco and India (Figure 4).*Trichoderma* MI Isolate is showing 73% nucleotide identity with a *Trichoderma* spp. from China. Therefore, morphological identification combined with molecular analysis confirmed the isolated *Trichoderma* isolate from onion field as *T. asperellum.*

The phylogenetic tree obtained through sequence analysis of ITS1 of isolated *Trichoderma* sample (*Trichoderma* MI Isolate) and the sequences of 20 other *Trichoderma* spp. obtained from sequence databank (NCBI) is represented in Figure 5. *Trichoderma* MI Isolate is allocated in the tree with the type strain of *T. asperellum.* Only the *Trichoderma* spp. (Accession No. MH284676) reported from China separated in cluster formation of the phylogenetic tree.

Different *Trichoderma* isolation studies conducted in Sri Lanka found that Sri Lanka soil is rich in *T. asperellum* strain and showing antagonism against different plant pathogens (Wijesinghe *et al*., 2010; Rajapakse *et al*., 2016). Isolation of bio control agent from the targeting application is important for the sustainability of the final bio pesticide. Hence this local available *T. asperellum* is an important source for the mass production of *Trichoderma*.



Trichoderma Isolates	**Trichoderma MI Isolate**	T. asperellum; KU987249	T. asperellum; KU987252	T. asperellum; KU987246	Trichoderma sp.; H284541.1	T. asperellum; KU987245	Trichoderma sp.;MH284502	T. asperellum; KY659050	T.asperellum;KU987251	T. asperellum; KU215912.1	T. asperellum; KU215909	T.asperellum;KC859432	Trichoderma;MH284666	Trichoderma sp.;MH284564	Trichoderma sp.;MH284556	T. asperellum; MF383124	T. asperellum; KT876619	Trichoderma sp.;MH284676	T. asperellum; KT876548	T. hamatum; LN846702
Trichoderma MI Isolate	1.00																			
T. asperellum; KU987249	0.95	1.00																		
T. asperellum; KU987252	0.95	1.00	1.00																	
T. asperellum; KU987246	0.95	0.99	1.00	1.00																
Trichoderma sp.; H284541.1	0.94	0.97	0.97	0.96	1.00															
T. asperellum;KU987245	0.91	0.94	0.94	0.94	0.92	1.00														
Trichoderma sp.;MH284502	0.94	0.98	0.97	0.97	0.99	0.92	1.00													
T. asperellum; KY659050	0.94	0.99	0.99	0.98	0.97	0.93	0.98	1.00												
T.asperellum;KU987251	0.94	0.99	0.98	0.98	0.97	0.93	0.98	1.00	1.00											
T. asperellum; KU215912.1	0.94	0.99	0.98	0.98	0.97	0.93	0.98	1.00	1.00	1.00										
T. asperellum; KU215909	0.94	0.99	0.98	0.98	0.97	0.93	0.98	1.00	1.00	1.00	1.00									
T.asperellum;KC859432	0.94	0.98	0.98	0.97	0.98	0.92	0.98	0.98	0.98	0.98	0.98	1.00								
Trichoderma;MH284666	0.93	0.98	0.98	0.98	0.97	0.93	0.98	0.99	1.00	1.00	1.00	0.98	1.00							
Trichoderma sp.;MH284564	0.93	0.98	0.98	0.98	0.97	0.93	0.98	0.99	1.00	1.00	1.00	0.98	1.00	1.00						
Trichoderma sp.;MH284556	0.94	0.99	0.98	0.98	0.97	0.93	0.98	1.00	0.99	0.99	0.99	0.97	1.00	1.00	1.00					
T. asperellum; MF383124	0.93	0.98	0.98	0.98	0.97	0.93	0.98	0.99	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00				
T. asperellum;KT876619	0.93	0.98	0.98	0.98	0.97	0.93	0.98	0.99	1.00	1.00	1.00	0.98	1.00	1.00	1.00	1.00	1.00			
Trichoderma sp.;MH284676	0.73	0.75	0.74	0.74	0.74	0.78	0.74	0.75	0.75	0.75	0.75	0.74	0.75	0.75	0.75	0.75	0.75	1.00		
T. asperellum; KT876548	0.93	0.98	0.97	0.97	0.96	0.92	0.96	0.98	0.99	0.99	0.99	0.97	0.98	0.98	0.98	0.98	0.98	0.75	1.00	
T. hamatum;LN846702	0.92	0.96	0.95	0.95	0.94	0.91	0.95	0.96	0.96	0.96	0.96	0.94	0.96	0.96	0.97	0.96	0.96	0.75	0.95	1.0
T. asperellum; LN846686	0.93	0.98	0.98	0.98	0.96	0.93	0.97	0.99	0.99	0.99	0.99	0.97	0.99	0.99	0.99	0.99	0.99	0.75	0.98	0.9

Figure 4: Comparison of the sequences data of the *Trichodrma* MI Isolate with selected sequence data available at the NCBI

The evolutionary history of *Trichoderma* MI isolate was inferred using the Neighbor-Joining method (Saitou and Nei, 1987). The optimal tree with the sum of branch length = 0.08701120 is shown. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Tamura-Nei method (Tamura and Nei, 1993) and are in the units of the number of base substitutions per site. The analysis involved 21 nucleotide sequences. All positions containing gaps and missing data were eliminated. There were a total of 266 positions in the final dataset. Evolutionary analyses were conducted in MEGA6 (Tamura *et al*., 2013).

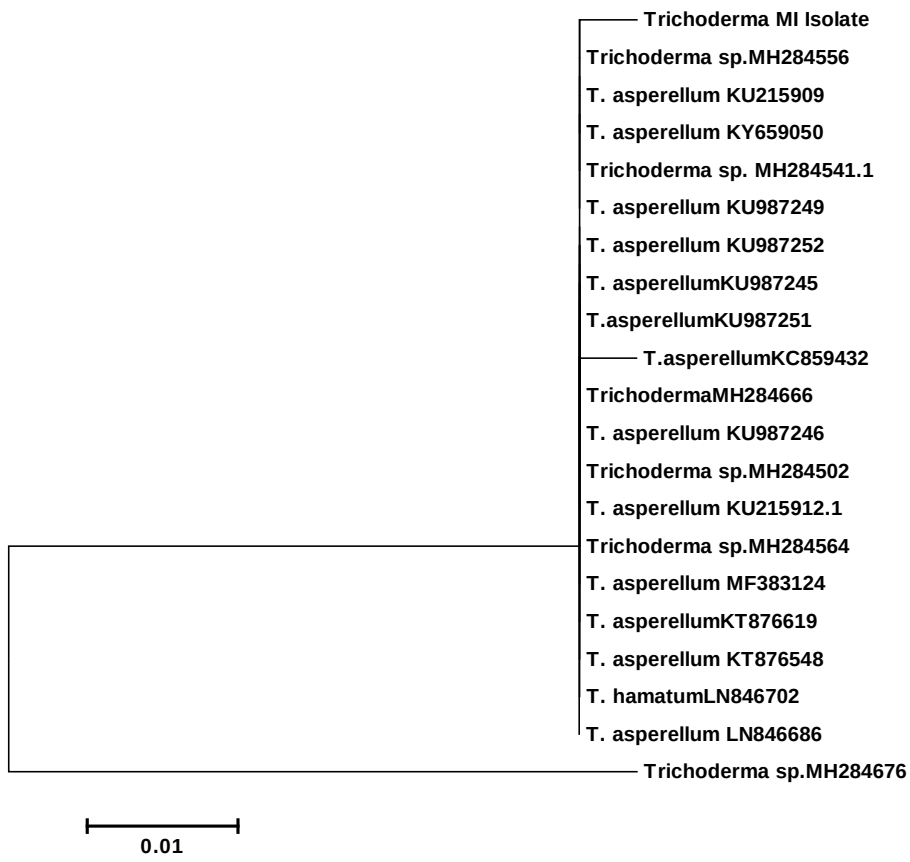


Figure 5: Evolutionary relationships of *Trichoderma* MI isolate with similar*Trichoderma* spp.

Evaluation of the mass culturing media for Trichoderma

Mycellium growth was observed within one day after inoculation of *Trichoderma* in sweet sorghum medium. Within 3 days sorghum and cracked maize grains media were with mycelium. Other media took 5-6 days to show mycelium prominently. Conidial yield count using heamocytometer was started 7 days after *Trichoderma* inoculation and initial count showed significant difference among different treatments ($p < 0.05$). The highest colony forming unit ($1.55x10^8$cfu/g) was observed in sweet sorghum medium on 7 days post inoculation (Table 1).

Table 1: Conidial yield of *Trichoderma MI isolate* in different media after inoculation

Treatment	Conidial yield (cfu/g) in Days After Inoculation (DAI)			
	7 DAI	10 DAI	14 DAI	17 DAI
Sorghum grains (T1)	5.4×10^7 b	6.65×10^7 b	7.75×10^7 b	2.65×10^8 bc
Sweet sorghum grains (T2)	1.55×10^8 a	2.66×10^8 a	4.33×10^8 a	1.02×10^9 a
Cracked maize grains (T3)	5.1×10^7 b	7.2×10^7 b	8.35×10^7 b	3.43×10^8 b
Rice bran (T4)	8.5×10^6 c	1.3×10^7 c	1.01×10^8 c	1.28×10^8 cd
Cow dung (T5)	1.05×10^7 c	2.05×10^7 c	3.35×10^7 c	5.75×10^7 d
Rice straw (T6)	9.0×10^6 c	2.35×10^7 c	6.85×10^7 c	8.8×10^7 cd
Dried banana leaves (T7)	9.0×10^6 c	2.2×10^7 c	4.5×10^7 c	6.8×10^7 d
CV	19.8	14.8	12.3	16.4

According to the results of the table sorghum grains and cracked maize grains also showed better results compared with other selected media to grow *Trichoderma*. According to the Tewari and Chandrabanu (2003) rice straw resulted 4.95×10^8cfu/g and Hari and Somasekhar (1998) reported that sorghum grains gave 5×10^8cfu/g of yield. Thangavelu *et al*. (2003) reported dried banana leaves produce yield of 4.6 $\times 10^{32}$cfu/g of leaf. Sorghum grains and rice straw media achieved higher yield than in previous study results while the dried banana leaves did not. According to the standards of *Trichoderma* formulations *Trichoderma* spp. should have minimum 2×10^6 cfu/g on selective medium (Ramanujam *et al*., 2010). All media tested produced more than the minimum number of *Trichoderma* yield. However, comparatively higher yield of bio control agent within short period of time is important for the effectiveness of the bio product. Results clearly indicated that out of the seven media tested sweet sorghum grains yielded high cfu/g in every count showing significant difference with other media and it reached up to 1.02×10^9 cfu/g within 17 days. However it gave enough *Trichoderma* yield within 7-10 days after inoculation and this can be further increased by adding nutritional supplement to the media. Sweet sorghum is mostly used for the production of platform chemicals and biofuels as well as could be used as a raw material for electrical energy production in microbial fuel cells (Sjoblom *et al*., 2017). No studies were found regarding use of sweet sorghum as a bio control fungi mass culture media though; other experimental media were prominently used by manufacturers and scientists. Sweet sorghum juice usually contains approximately 16–18% fermentable sugars, which are mainly comprised of sucrose, glucose and fructose (Jia *et al*., 2013). The soluble sugar content in sweet sorghum may act as good mass culturing media. Hence, sweet sorghum can produce enough bio control fungi yield without adding any nutrient supplement. Thus this study indicated that sweet sorghum

may be used as an effective and efficient media for the mass culturing of *Trichoderma* with or without nutrient supplement.

Conclusions

Based on the molecular confirmation isolated *Trichoderma* was identified as *T. asperellum* and is similar to *T. asperellum* found in other parts of the world. Results indicated that sweet sorghum has potential for use as an effective mass culturing media for *Trichoderma* mass multiplication and nutrient supplement addition and sustainable application should be further studied.

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