

NONI SEARCH **2007**

Proceedings of Second National Symposium on Noni for Health and Wellness

Edited by

Dr. P. Rethinam

Former Executive Director

Asian and Pacific Coconut Community (Jakarta)

Coimbatore



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Contents

S.No.	Title	Page No.
1.	Foreward	vii
2.	Preface	ix
3.	Welcome Address - Prof. P.I. Peter	xi
4.	Presidential Address - Dr. Kirti Singh	xiii
5.	Inaugural Address - His Excellency Thiru Surjit Singh Barnala	xix

Contributed Papers

1.	Micropropagation of <i>Morinda citrifolia</i> , L. Dr. J. Subramani, S.Antony Selvaraj, D.Vijay, M.Sakthivel, M.Umashanthi	1
2.	Creating Livelihood through Technological Interventions in Enhancing Productivity of <i>Morinda citrifolia</i> L. (Noni) in Bay Islands R.C.Srivastava and D.R.Singh	7
3.	Peptide and Mineral profile of <i>Morinda citrifolia</i> fruits and leaves D.R.Singh, Jai Sunder and R.C.Srivastava	18
4.	A Study Involving the Production of <i>Morinda citrifolia</i> L. (Noni) by Small Farmers in A & N Islands, India D.R. Singh, S. K. Zamir Ahmed and R C. Srivastava	27
5.	Economic Appraisal of <i>Morinda citrifolia</i> L. (Noni) Cultivation in Bay Islands Subhash Chand, D.R. Singh, R.C. Srivastava	36
6.	Noni – (<i>Morinda citrifolia</i> L.) Organic Farming System and Viable Models MA. Palanichame	44

7.	Evergreen Revolution in Agriculture through Organic Farming Systems R.K. Pathak	49
8.	Effect of Growth regulators on rooting of hollow and non hollow cuttings of <i>Morinda citrifolia</i> L. D.R.Singh, R.C. Srivastava and T. Damodaran	57
9.	Effect of Pre-sowing treatment on seed germination and seedling vigour in <i>Morinda citrifolia</i> var. <i>citrifolia</i> , an indigenous medicinal fruit suitable for Tsunami affected land D.R.Singh, R.C.Srivastava, R.Sudha and T.Damodaran	62
10.	Studies on growth and development stages of <i>Morinda citrifolia</i> L. (Noni) fruits D.R.Singh, R.C. Srivastava, and R. Sudha	70
11.	Influence of Noni (<i>Morinda citrifolia</i> L.,) herbal extracts on growth and production of chillies var. Arka Lohit D.R.Singh, R.C. Srivastava, V. Jayakumar and V.B. Pandey	76
12.	Studies on shelf life and biochemical changes of <i>Morinda citrifolia</i> L. (Noni) fruits during storage D.R. Singh, R.C.Srivastava, R. Sudha, and Abhay K. Srivastava	84
13.	<i>Morinda citrifolia</i> L., (Noni) – A viable alternative for Tsunami affected agricultural lands D.R.Singh, R.C.Srivastava and R.Raja	92
14.	Need and Scope for Evolving Holistic and Organic Crop Protection Options for Noni (<i>Morinda citrifolia</i> . L.) S. Sithanatham and N. Mathivanan	103
15.	Cues for ISR and Trophic Interactions of PGPR and their Possible Applications for the Management of Pests and Diseases of Noni (<i>Morinda citrifolia</i> . L) T. Marimuthu and S. Nakkeeran	121
16.	Bionomics and population dynamics of <i>Dulinius conchatus</i> Distant (Tingidae : Heteroptera), a pest of <i>Morinda tinctoria</i> * S. Dhanasekaran, M. Selvanayagam and B.Vasantharaj David	141

17.	Evaluation of <i>Morinda citrifolia L.</i> (Noni) extract on production and immune response in poultry Jai Sunder, D.R.Singh and A.Kundu	159
18.	Development of Noni (<i>Morinda citrifolia L.</i>) based Nutraceuticals for Health Security P.N. Satwadhar, A.N. Siddiqui and H.W. Deshpande	167
19.	Effect of NONI (<i>Morinda Citrifolia L.</i>) on Ethylene Glycol Induced Nephrolithiasis in Rats A. J. M. Christina, Neelesh Kumar Varma, N. Chidambaranathan N. Muruges	177
20.	Scientific Validations for Therapeutic Benefits of Noni (<i>Morinda citrifolia, L.</i>) Dr. N. Muruges	183
20.	Role of Noni (<i>Morinda citrifolia L.</i>) in Spondylotic Myelopathy Dr. Rangadhar Satapathy	193
21.	Role of Noni (<i>Morinda citrifolia L.</i>) in Rheumatoid Arthritis Dr. Rangadhar Satapathy	203
22.	Effects of Noni (<i>Morinda citrifolia L.</i>) on Carcinoma of Breast Dr. Rangadhar Satapathy	209
23.	Effect of Noni on Filarial Worm Infestation – In Vitro Study Dr. Rangadhar Satapathy	216
24.	Studies of Comparative Anti-HIV Activity and cytotoxicity of <i>Morinda citrifolia L.</i> Periyasamy Selvam, Narayanan Muruges, Myriam Witvrouw	220
25.	Cytotoxicity in Human Retinoblastoma Y79 cells by the fruit extract of Noni (<i>Morinda citrifolia L.</i>) G. Surendiran, T. Seetha Lakshmi, K. Malikarjun S. Krishnakumar and N. Mathivanan	224

FOREWORD

World Noni Research Foundation (WNRF) in its first attempt to disseminate the knowledge on all aspects of Noni (*Morinda citrifolia*, L) and create the awareness of the beneficial effects of Noni, organized the First National Symposium on Noni Search at Hyderabad, India, on October 7 and 8, 2006 and brought out the Proceedings in 2007. I am now happy to bring out the Proceedings of the Second National Symposium, the Noni Search 2007, which was held at Chennai on October, 27 and 28, 2007 with the theme on Noni for Health and Wellness.

The Indian Noni, *Morinda citrifolia* L., commonly known as the Indian Mulberry belonging to the *Rubiaceae* family, is found grown everywhere as wild plant not only in India including Andaman Islands but also in many Asian and Pacific countries. It is now becoming a cultivated crop in the country.. *Morinda citrifolia* L., commonly called as Noni, contains numerous phytochemicals, several vitamins, micro and macro nutrients which help our body in various ways from cellular to organ levels. This plant with lot of medicinal uses which are known for more than 2000 years, has attracted the attention of many Doctors, Physicians and pharmacologists. Therapeutic uses as well as the success stories recorded by many researchers and medicinal practioners on the use of Noni are also pouring and larger section of health conscious people are showing interest in using noni juice and other products.

WNRF, a non-profit and self-sustaining independent body promotes research for generating scientific knowledge up to molecular level on all aspects of Noni plant and its uses such as neutraceuticals, pharmaceuticals, cosmoceutical uses, clinical, phytochemicals and pharmacological studies. This organization also provides a platform for Noni Research to create wellness among people and improve Noni towards sustainable human and ecological health.

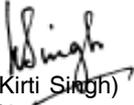
WNRF believes that this synergistic effort of scientists and doctors of Noni solidarity would empower millions of ordinary people to find their dignity in leading a healthy life and experience economic freedom, more naturally.

My hearty congratulations to Prof. P. I. Peter, the most dynamic Chairman, Health India Laboratories, Chennai for his concept of organising such symposium every year in the country not only to popularise the health benefits of this underutilized miracle fruit crop but also provide opportunities to the farming community to add another profitable crop in their farming system with assured market assistance. I appreciate the services rendered by the group of officials of WNRF in organizing this symposium successfully. I thank all the authors who had presented papers on various aspects which have brought out voluminous information on this crop.

I am sure that this proceedings of the theme based symposium will be more useful to many who are involved in Noni Research and Development, as well as to policy planners and also for those who want to know about this crop and its benefits.

I thank Dr. P. Rethinam, Former Executive Director, APCC, and Advisor, WNRF valuable Dr. K.V. Peter, Director WNRF and Former Vice Chancellor, KAU for their help in bringing out this publication.

Chennai
July, 2008.


(Kirti Singh)
Chairperson
WNRF, Chennai.

PREFACE

Noni Search 2007, the Second National Symposium on Noni with a theme on Noni for Health and Wellness was held on October 2007 at Chennai. I have great pleasure in compiling, editing and bringing out the Proceedings which is the follow up of the ever first historic symposium, Noni Search 2006, held at Hyderabad during October 2006.

This symposium had many invited papers from eminent Scientists, Research Scholars, Medical Doctors and Pharmacologists. The papers were focused on crop production, protection, processing and clinical as well as health aspects. Many success stories were also presented.

This second symposium had six scientific sessions besides the Inaugural session and plenary sessions. Altogether there were 43 presentations on Noni, on crop improvement, including, micropropagation, production, plant protection, chemical and biological properties of Morinda and pharmacological and clinical studies. 25 papers received are included in this proceedings.

This compilation is an another addition to the document on Noni which definitely will give lot of information about Noni and its products for health and wellness of human being. This will also be useful for researchers, scholars, planners and policy makers, who are involved in Noni.

I am grateful to Dr. Kirti Singh, Chairperson, WNRF for providing me opportunity, in editing this second proceedings. My sincere thanks to Prof. P. I. Peter, Chairman, Health India Laboratories as well as the architect of Noni Search 2007, for his start (constant) support in bringing out this very useful proceedings in time. I am grateful to all the speakers for their kind cooperation in sending their articles. Special thanks are due to Dr. K.V. Peter former Vice Chancellor, KAU, Trichur and the Director, WNRF, for his help in going through the proceedings. The help rendered by Mr. Antony Selvaraj for his untiring help in typing and helping me at all stages to bring out this document. Mr. Thanigai Kumar and Sri. M.S. Pandian helped a lot in designing the cover page and bring out this publication in the present form for which I gratefully acknowledge their help.

Chennai
July, 2008


(P. Rethinam)
Editor and Advisor, WNRF

Welcome Address by Prof. P.I. Peter

Chairman, Health India Laboratories

Your Excellency, Shri. Surjit Singh Barnalaji, the Governor of Tamil Nadu, Dr.Kirti Singh, Chairperson of World Noni Research Foundation, Dr.M.L.Choudhary, Horticulture Commissioner, Government of India, esteemed invitees, distinguished delegates to the NONI SEARCH-2007 the Second National Symposium on Noni Research organized by World Noni Research Foundation, Media and Press, Ladies and Gentlemen.

I consider it a distinct honour to extend a warm welcome to Your Excellency, the Governor of Tamilnadu, Shri. Surjit Singh Barnala on behalf of all the Delegates, invitees of this symposium and on my own behalf. Our Governor His Excellency, Shri. Surjit Singh Barnala is a rare combination of sterling qualities and coveted distinctions, - a distinguished administrator, great humanist and a nationalist to the core. By your kind presence, Sir, you have also bestowed a singular honour to the NONI SEARCH-2007 Second National Symposium on Noni Research which, I am sure, shall further inspire us to accomplish the Vision and Mission of World Noni Research Foundation.

I welcome our beloved Chairperson, Dr. Kirti Singh, World Noni Research Foundation who has pioneered this symposium, Noni Search 2007.

I welcome Dr.M.L.Choudhary, Horticulture Commissioner, Government of India Distinguished Scientist who is here as the Guest of Honour for the inaugural session of the Symposium.

I welcome the members of World Noni Research Advisory Board -Dr.K.L.Chadha, Dr.S.Kannaiyan, Dr.K.Pradhan, Dr.S.S.Kadam, Dr.(Mrs)P.Geervani to Noni Search 2007 the Second National Symposium.

My special welcome to Dr.K.V.Peter, Member Secretary, WNRF and Dr.P.Rethinam, Consultant of WNRF who have been proactively guiding in organizing Noni Search 2007. The success of this historical event is mainly due to their extraordinary support and guidance.

I welcome Dr.R.C.Srivastava and all scientists including Dr.D.R.Singh from Central Agricultural Research Institute who have come all the way from Port Blair, Andaman and Nicobar Islands.

A very hearty welcome to the Chairmen, Co-Chairmen, Rapporteurs, Lead Speakers and Speakers and the Scientists presenting poster papers of the Symposium specially those who have come from different parts of our country.

I welcome the media persons who have spared their time to be with us.

I take great pleasure in extending a very warm welcome to members of the WNRF Research Council, Researchers, Doctors, Delegates of the Symposium, Cultivators and Noni users.

On behalf of WNRF and Health India Laboratories, I am extremely delighted to welcome each and everyone present on the happy occasion.

Noni search 2007 is the second annual event of WNRF to recognize the research done by Doctors and Scientists and it is a scientific platform to present and discuss their valuable research findings with the experts in different fields. I consider the research work done on Noni is a true contribution to the future of humanity.

Noni Search 2007 will focus on the theme “Noni for Health and Wellness”.

I request you to take the message of the Noni Search 2007 and share with people around you to spread awareness about the potential of Noni to create good health and wellbeing..

I once again take the privilege of welcoming whole heartedly each and everyone of you who have come to attend Noni Search 2007 the Second National Symposium on Noni Research at Chennai on this history making day.

I wish the delegates a happy and memorable stay at Chennai.

Thank you.

Jai Hind

Presidential Address by Dr. Kirti Singh

Chairperson, World Noni Research Foundation

Your Excellency Shri Surjit Singh Barnalaji, the Governor of Tamil Nadu, Dr. M.L. Choudhary, Horticulture Commissioner, Government of India, Prof. P.I. Peter, Chairman, Health India Laboratories, Honoured Members of Research Advisory Board of World Noni Research Foundation, Eminent Scientists, Doctors, Pharmacologists, other dignitaries, delegates, Media, Press, Ladies and Gentlemen.

A very pleasant NONI morning to you all. Today, we all have assembled here to participate in Noni Search 2007 – the Second National Symposium with the theme “Noni for Health and Wellness”. We are most fortunate to have our Honoured Chief Guest H.E.the Governor of Tamil Nadu for inaugurating this most unique conference. Our Chief Guest is known to me ever since he was the Union Minister of Agriculture, Government of India. He is a dynamic personality and well known for his contribution to the development and prosperity of our great nation. He has always appreciated the scientists for their contribution in making the country self-sufficient not only on food front but also in many other fields as well.

Your Excellency, we are extremely grateful to you for having accepted to inaugurate the Noni Search 2007 in spite of your hectic daily schedule. We feel honoured with your august presence. We are very eagerly waiting for your inaugural address which will give us many future directions on the research and development and the role that this wonder plant will play in our country’s “Health and Wellness” programme.

I had the opportunity to inaugurate and attend the First National Symposium, Noni Search 2006, at Hyderabad in October 2006 and the Proceedings of the Symposium will be released by our Chief Guest today. Over a period of years, a treasure of information on Noni has been collected and compiled by Prof. P.I. Peter and the same has been edited as Noni Monograph which also will be released today.

The World Noni Research Foundation is the brain child of Prof.P.I.Peter and is a non-profit, self-sustaining, independent, registered trust of likeminded scientists who believe in generating scientific knowledge upto the molecular level on various aspects of this plant. The Foundation has six research programme areas namely Crop Research, Plant Protection Research, Food Science Research, Clinical Research, Pharmacological and Experimental Research. Each research programme area is headed by an eminent scientist. With my involvement as Chairperson, we are streamlining the research, strengthening the collaboration in various fields like agriculture, bio-science and medical science and also organize symposium. Noni Search 2007 is being attended by agricultural scientists, bioscientists, biotechnologists, medical doctors, pharmacologists and farmers who are growing Noni for sustainable income, a few promoters of Noni, consumers of Noni for health and wellness, planners and policy makers and they all will also deliberate and discuss various issues pertaining to Noni for two days in Six Technical Sessions viz., Crop Improvement, Crop Production, Crop Protection, Post Harvest Technology and Noni for Health including Pharmacological, Clinical and Therapeutic aspects.

I do not want to take much of your time. I only would like to say that *Morinda citrifolia* L., the underutilized but wonder fruit crop with full of nutrients is slowly vanishing due

to genetic erosion. It is the right time that we have to conserve the genetic diversity and make use of this fruit and other parts of this plant in Wellness program for not only human beings but also in cattle, poultry and fishery. Before I conclude, I would like to say that Noni is the Fruit of the 21st Century” in providing Nutritional Security and Wellness Security to millions of people around the world and also provide sustainable income to the farmers.

Once again I express my gratitude to Your Excellency for the kindness shown to us by participating in this vital symposium and inaugurating the same.

I am sure that the delegates will find the deliberations of the symposium interesting and useful. Finally, I have every hope that the outcome of the symposium will add to the existing knowledge and pave way for further research on Noni.

Noni Namashkar

Jai Hind

Inaugural address by Thiru Surjit Singh Barnala,

His Excellency the Governor of Tamil Nadu, at the Inauguration
The Second National Symposium on '**Noni For Health and Wellness**'
at Image Auditorium, Chennai on 27.10.2007 at 10.30 a.m.

I feel it a great pleasure to inaugurate the Noni Search 2007 - the Second National Symposium on "Noni For Health and Wellness" organized by the World Noni Research Foundation here today.

India has a rich heritage of medical and health knowledge. Health is one of the key aspects for prosperity. Various traditional systems of healthcare are in use in India even today. The distinguishing feature of our ancient systems is that they are holistic in nature. Health depends on the presence or absence of a balanced state of the body. Loss of equilibrium is caused by dietary indiscrimination, undesirable habits and abstaining from the rules of healthy living. As Hippocrates said. "Food is medicine". One should take healthy food rich in nutrients. Untimely, spicy and high cholesterol food destabilizes the health of a person which is the most valuable possession for a human being.

World Health Organisation reports reveal that about 54% of World's Women and Children are anemic. Kerala, Tamil Nadu & Karnataka have more diabetic patients. One out of three persons are under the threat of heart disease. Hospitals are filled with patients. We may boast that Charaka and Susrutha were born in India and India is home to Ayurveda Siddha & Unani System of practice but what we need is an individual approach by every one to healthcare.

It is heartening to note that now people are showing significant attention to their health care and wellbeing. Undue stress, malnutrition and unbalanced food lead to diseases. This symposium is of great significance and very timely.

I am happy to learn that the plant 'Indian Noni' popularly known as Indian mulberry provides a lot of health benefits and is native to India and is grown in Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Orissa, Madhya Pradesh and Andaman & Nicobar Islands. I am told that this wonder plant Noni possesses more than 150 health promoting nutrients, 17 to 20 essential amino acids, Vitamins, minerals and the much required antioxidants and the whole plant, right from its roots, stem, leaves and fruits are used for human wellbeing. The fruits, particularly have wide range of therapeutic potential and are used as anti bacterial anti viral, anti tumor, analgesic, anti inflammatory and for immune enhancing effects. I am also pleased to know that this under exploited and under utilized plant Noni is traditionally used by the Palynesians for centuries as food and medicine and its use dates back to more than 2000 years. It is said that in Andaman & Nicobar Islands, the tribals consume this fruit raw with common salt and cook as vegetable.

I am happy to learn that the European Union has accepted Noni juice as novel food. Commercial interest in Noni has increased greatly in recent years and it is learnt that there are 19 patents registered in the U.S. Patent and Trade Mark office alone since 1976. In India, we are not much aware of its potential and its divine power to result in healthy life without medication. Noni is described as God's Gift for a healthy and well-cared human body.

It is heartening to note that World Noni Research Foundation has started facilitating research on organic cultivation, product development, validation of indigenous knowledge on the properties of this plant and for clinical and pharmacological studies by Doctors in the concerned field.

I am told that the product development division of Health India Laboratories has come out with over 168 wellness Noni products not only for nutrient supplementation but also for use in pharmaceuticals and cosmeceuticals. I also understand that

many of the doctors of Allopathy, Homeopathy and Ayurveda have studied the effect of Noni products and have brought out many success stories and testimonials in managing diabetes, arthritis and other diseases and disorders.

I hope that the Pharmacologists in the WNRF funded projects would concentrate on developing value added health and wellness products using Noni and register these products not only in India but also in other parts of the world. I am sure that the National and State medicinal Plants Boards will look into the medicinal and preventive uses of Noni and include it in their list of plants.

I congratulate World Noni Research Foundation and the Health India Laboratories for their valid efforts in creating awareness on the uses of Noni and for taking up research and development work in this crop and for support extended to farmers to grow this crop.

I am sure that the galaxy of scientists, researchers, medical practitioners and other eminent and experienced personalities who have assembled here will formulate strategies for future Research and Development and also take the message for health benefits of Noni.

I convey my warm felicitations to the organizers and all the participating delegates and wish “Noni Search 2007” all success.

Jai Hind.

Micropropagation of *Morinda citrifolia*, L.

Dr. J. Subramani¹, S. Antony Selvaraj², D. Vijay³, M. Sakthivel⁴, M. Umashanthi⁵

Abstract

The varying effect of Cytokinin and Auxin combinations on Morinda citrifolia for effective In-vitro induction of shoots from nodal explants were studied by using both WP and MS basal media. BAP alone with 2 mg/ltr. concentration found effective in both the basal media to initiate axillary shoot induction. Further BAP along with 1 mg/ltr Kinetin combination gave 4 - 5 multiple shoots from a single node with in a period of 2 weeks. Further by using leaf ex-plants, callus was induced. Actively growing yellowish callus was induced by using 2 mg/ ltr. 2,4-D. Further the initiated calli were Sub-cultured in MS basal containing 0.5 mg/ltr NAA to produce Rhizogenic calli with lots of roots at periphery. These calli mass with roots in BAP and KN media combination, became Organogenesis and resulted in producing shoot(s).

Keywords : Morinda sp, Nodal explant, multiple shoots, rhizogenic calli.

Introduction

***Morinda citrifolia* L.** commercially known as Noni, grows widely through out pacific and is one of the most significant sources of traditional medicines among pacific island societies. (M.Clatchey, W.2002; Nelson, S.C.2001). The botanical name for the genus was derived from two Latin word Morus, mulberry and indicus, Indian, in reference to the similarity of the fruit of Noni to that of true mulberry (*Morus alba*) belongs to the family Rubiaceae (Morton, J.1992).

1. Crop Research division of WNRF
2-5. INRF, chennai-119

Noni is relatively easy to propagate from seeds, stem or root cuttings and air layering. The preferred methods of propagation are by seeds and by cuttings made from stem verticals (Nelson, S.C 2001). Till date, not much work on In-vitro propagation by using Tissue culture techniques were carried out in this plant. Preliminary studies on In-vitro propagation of *Morinda citrifolia* L. was attempted at our centre for the past one year.. Both the nodal explants and rhizogenic calli have given shoot(s) in both the WP and MS media with the combination of Cytokinin and Auxin.

Materials and Methods

Plant Material :

Seeds of *Morinda citrifolia* L. brought from the Western Ghats, India were sown in the gardens of Health India Laboratories, Sholinganallur. Two leaf stage plants were brought to Tissue Culture Laboratory and used for explant collection. Apical regions and Nodal explants were used.. Young leaves were used for callus initiation.

Sterilization Details :

a) Nodal explant :

The nodal explants were collected from 6-8 months old seedlings. Top 3 nodes were taken for tissue culture purpose by leaving the basal single node in the mother plant.. Due to the removal of upper axillary buds, the axillary region sprout very efficiently by producing two axillary sprouts in-vivo within 8-10 days..

b) Procedure :

Top 3 nodes were taken then washed with sterile water and kept in 1:2 (Sodium hypochlorite: Sterile water) with constant stirring for 30 minutes. The ex-plants were washed 3-4 times with sterile water then treated with 0.1% mercuric chloride for 5 minutes and rinsed with sterile water before inoculation.

c) Leaf ex-plant :

The above sterilization treatment was given for leaf ex-plant also to initiate callus.

Media Details :

Following basal media with various combinations of Cytokinin and Auxin were tried in our In-vitro studies. Refer Table 1, 2 & 3.

Table 1. For In vitro Multiplication

MEDIA	BAP(mg/l)	KN(mg/l)	IBA(mg/l)
MS	2.0	-	-
	4.0	-	-
	1.0	1.0	-
	2.0	0.75	2.0
	1.0	0.25	-
WP	2.0	-	-
	4.0	-	-
	2.0	1.0	-
	2.0	-	2.0
	2.0	0.5	-

Table 2. For callus initiation and regeneration from Leaf Explants

MEDIA	2,4-D(mg/l)	NAA	IAA	IBA	BAP	KN
MS	2.0	-	-	-	-	-
	-	0.5	0.1	-	-	0.5
	4.0	-	0.5	4.0	1.0	-
	-	-	1.0	2.0	3.0	1.0
	-	-	-	1.0	4.0	-
WP	2.0	2.0	-	-	-	-
	-	-	0.1	-4.0	-	0.5
	4.0	-	-	2.0	2.5	1.0
	-	-	0.5	1.0	2.0	-
	-	1.0	1.0	-	3.0	-

Table 3. In vitro rooting

MEDIA	IBA(mg/l)	IAA (mg/l)	NAA(mg/l)
MS	1.0	0.1	0.1
	2.0	0.3	0.3
	4.0	0.5	0.5
WP	1.0	0.1	0.1
	2.0	0.3	0.3
	4.0	0.5	0.5

Result & Discussion

Shoot initiation :

Both Ms and WP media were used along with various combinations of Cytokinin and auxin. Axillary bud sprouting was observed in both the basal media with 2.0 mg/l BAP alone. (Fig. 3 & 4)

Multiplication in vitro :

After four weeks of axillary bud sprouting, initiated young shoots along with the nodal region were transferred to multiplication media. BAP 4.0 mg/l, along with IAA 0.5 mg/l have produced 3-5 multiple shoots within 4-6 weeks after subculture (fig.5). Both MS basal and WP found equally good enough for culture multiplication. Culture was allowed to grow at $26\pm 2^{\circ}\text{C}$ temperature and humidity at $55\pm 10\%$ photoperiod 16hrs light and 8hrs dark. Light intensity of 2000lux.

In vitro rooting :

Out of MS and WP basal media used, MS basal with 1.0 mg/l IBA and 0.5 mg/l NAA have produced enough roots in vitro (Fig. 6). 4cm to 6cm long shoots were removed separately from the multi culture and inoculated in the rooting media. MS media with 1.0 mg/l IBA

and 0.5mg/l NAA used in the rooting media. Individual plants with roots were transferred to green house for hardening.

Hardening at green house :

Well rooted plants were transferred to protrays (98 cavities) containing coco-peat (Fig. 7). After hardening for 5-6 weeks, young plantlets were transferred to Nursery stage (Fig. 8). Green house temperature was maintained at $32 \pm 4^{\circ}\text{C}$ and humidity $60 \pm 20\%$.

Callus Initiation :

2mg/l 2,4-D in both MS and WP media were found to be ideal for callus initiation (Fig.9). Calli were further maintained in media containing 2mg/l 2,4-D(Fig.10).

Callus regeneration :

(a) Callus from MS/WP media were further sub-cultured on media (MS/WP) containing 4mg BAP, 0.5 mg/l kinetin that resulted in formation of single shoot in 25 days. (Fig.11).

(b) Further the rhizogenic Calli when subculture to media with 2.0mg/l BAP, 1mg/l kinetin and 0.1mg/l IAA resulted in multiple shoot formation(Fig12).

Summary :

The above preliminary studies clearly indicates that irrespective of the basal media used (either MS or WP), it is the hormonal combination are very vital for the In-vitro response. BAP alone for shoot initiation, BAP along with IAA for multiple shoot formation. IBA along with NAA have given good rooting in- vitro. Rooted plants have established well with 95-98% survival at Green house while hardening. Further better growth with zero percent mortality was observed at nursery stage. Calli with roots produce shoot(s) in BAP with KN.

The idea of this whole study is to standardize the viable commercial protocol for mass multiplication of ELITE CLONES of *Morinda citrifolia* in future for our corporate farming.

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Creating Livelihood through Technological Interventions in Enhancing Productivity of *Morinda citrifolia* L. (Noni) in Bay Islands

R.C.Srivastava¹ and D.R.Singh²

Abstract

*Out of the total cropped area of 50,000 ha, horticulture and plantation crops occupy around 75%. As the cropped area is less for further development, selected high value crops have to be grown with suitable technologies to achieve high productivity so that the purchasing power of the farmers can be improved without endangering the fragile ecosystem. The Tsunami Tides on (26th December, 2004) stroked over in an area of about 10,000ha in the Andaman and Nicobar Islands, which has affected the livelihood of the local farmers. Of this about 4000 ha area are affected with saline water and about 2000ha are submerged on low lying areas due to high tides and 2000 ha area have been completely water logged due to Tsunami. In these areas the salinity has gone very high and therefore, it was a big challenge for the scientists for identification of suitable economic plants/crops, which can tolerate salinity as well as restore the livelihood of the affected farmers. Livelihoods are best examined through Sustainable Livelihood Framework (SLF), which is based on the premise that livelihood is not about resource productivity but it is about people and their lives. Livelihoods are sustainable when they are; (a) resilient to shocks and stresses (b) independent of external support (c) maintain the productivity (d) do not adversely affect the livelihoods of others. Based on the research work carried out by CARI supported research in A & N Islands, it was found and that the indigenous medicinal fruit plant *Morinda citrifolia* based livelihoods cannot only become*

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poverty reducing, it can also be made socially equitable and gender balanced and also has adaptations with specific kinds of stresses such as diseases, drought salt etc. However, the technological interventions have to be carefully designed to enhance the diversify livelihood strategies with a focus on developing a suitable package of practices of the cultivation of Morinda citrifolia to achieve high productivity by considering the following points: (a) improving marketing linkages (b) landscape-scale management practices that protect or enhance bio-diversity (organic farming, intercropping, mixed farming, water management (c) other important practices like selection of planting material , high density planting, canopy management, Rejuvenation of old trees, crop regulation, root stock, cropping pattern etc.

Introduction

Andaman and Nicobar Islands shimmer like emeralds in the Bay of Bengal, a total of 572 islands, islets and rocks, with only 38 inhabitable islands. Andaman and Nicobar islands have unlimited ecological treasures , are endowed by finest tropical evergreen forests in the world and are home to large number of rare and endangered flora and fauna with rich biodiversity. Tsunami has changed lives of thousands of people in the islands since it struck on 26th December 2004. Tsunami has completely shattered the livelihood of about 10,000 households, directly affecting about 50,000 people. For past two years, post tsunami, there has been lot of activity in around the Andaman and Nicobar islands. Due to ingress of the sea water into the low lying cultivated fields, the soil become unfit for cultivation in large tracts of these islands. Large number of coconut, areca plantations have been affected. About 10,000 hectares of agricultural land got affected. Standing vegetable/paddy crops have been damaged in about 3950 hectares. (Sunita Reddy, 2007). The Central Agricultural Research Institute, Port Blair has taken up a tough challenge of recovery of the affected agricultural land. And Great Morinda was a shining armor in the dark night. During the survey to various tsunami affected areas of the islands, it was found that this magical plant survived at its best under extreme salinity stress condition. In Bay Islands, the morinda plant is most popular among the tribals and the local people because of its medicinal value. In Andamans, it is nicknamed as burmaphal, lorang etc. It is widely distributed along the coastal areas, rocky shores, wastelands and backyards of Andaman and Nicobar islands. (Singh *et.al.*, 2005). It is

estimated that one hectare of land cultivated wasteland can generate A&N Islands annual income of approximately Rs.2 lakh and year round employment for five people. This would enhance aesthetic value of the islands and generate livelihood options. Livelihood is best examined through sustainable livelihood Framework (SLF), which is based on the premise that livelihood is not about resource productivity, but its about people and their lives. The paper put forwards that, Morinda cultivation will not only boost the livelihood strategies, through improving marketing linkages, protecting or strengthening the bio-diversity , but this fruiting plant, can enhance the aesthetic values of the islands, which will link forest and tourism and also generate livelihood options by means of employment.

Multi faceted Importance of *Morinda citrifolia L.*

The Social Perspective

In Andaman and Nicobar Islands, the use of Morinda fruit supplement (NONI) is meeting families primary health care and nutrition needs as the fruit contain all the essential nutrients. In Bay Islands, the Morinda plant is traditional and imbedded among the aborigines. This Tsunami has acted as an eye-opener for many islanders. After extensive research ,it revealed that this great Morinda plant tolerates high salinity, and in view of the above facts, this plant plays a important role in coastal stability, land reclamation and the protection of farms from salt water spray and also sea water inundated agricultural lands were restored by this magical plant. (Singh et al 2006). Consequently, this plant has been wholly recognized regarding the salinity tolerant power, commercial products (food supplement, toiletries, organic food for plants etc.) (Peter 2004), and private entrepreneurs to come up with marketing strategies. In the future, after the processing industry and proper marketplaces with transportation facilities are setup in the islands, it would become mainstay of medicinal plant based activities because the products and the activities will be socially acceptable with employment avenues. These activities include raw materials being collected, preserved, processed and transported. *Morinda citrifolia L.* has also been used to develop family based health and livelihood oriented enterprise in rural areas and the use of this plant among tribals specially the Nicobarese is still popular with their own traditional use as food or medicine. Perfect e.g. Arya Vaidya Sala, Kottakal in Kerala are excellent examples of business and traditional medicine service combined. Such type industries not only strengthen the

social framework, but also help a) preserve the traditional knowledge b) provide easily available enterprising opportunities for employed youth and rural poor who can learn. The trade from their parents and peers and earn not only their livelihood but also contribute to the society (Karki, 2000).

Protection of Traditional Knowledge

The necessity to protect the traditional knowledge of medicinal plants is important which is still abundant in all parts of the islands and cannot be overemphasized. The indigenous people of the Bay islands have rich local health traditions and have been practicing medicine for hundred of years. The conversion of socio-cultural traditions and indigenous knowledge into livelihood means and economic opportunities also has the advantage of preserving the rapidly eroding cultural knowledge and practices which are increasingly threatened due to globalization and homogenization of people and communities. It is evident that, Andaman and Nicobar are recognized to be the treasure trove of biological and cultural diversity, the product of million of years of evolution-there is need to protect indigenous knowledge (Singh et al 2007).

Environmental tolerances and perspective

According to the research Noni can tolerate wide range of precipitation patterns. It can grow in a wide range of soils and environments with a notable ability to survive in harsh environments, such as those found on coral atolls or ballistic lava flows. It can also be found in solution pits or brackish tide pools near the coast, in limestone soils or outcropping, on coral atolls, as a colonizing species of basaltic lava flows, as well as in native forests. Amazing characteristic, of Noni is that it can grow in wide range of acidic levels from shallow, saline and sodic soils. It can withstand and even thrive in brackish tide pools. It is tolerant to extreme salinity of ocean salts spray and it is thought to possibly gain nutritional benefits from the minerals contained in sea water. In reaction to competition, it is a good forest understory plant that can tolerate very harsh conditions and plant competitions from forest trees, infact it is one of the few plants that can thrive beneath the canopy of ironwood trees. In case of maintenance requirements, it is a low maintenance landscape plant.. Noni plants are not toxic to humans or animals, nor there any spines, horns etc on the plants and

Noni Search 2007 - Proceedings of Second National Symposium on Noni for Health and Wellness, Chennai.

without significant pest and disease attack morinda plant can survive for atleast 40-50 years and even longer (Nelson, 2005).

The expansion of medicinal plants based economic incentives are being increasingly applied to register greater participation of people in conservation of forest ecosystem.

Livelihood Importance of *Morinda citrifolia*

Morinda citrifolia L., has immense potential as the sustainable commercialization can benefit tsunami affected farmers as well as the local people and the tribally by providing higher price for the traditionally traded products and by opening up national and global markets for new products. Private sectors like Health India Laboratories, Chennai came forward to benefit the farmers by ensuring sustainable market for good quality raw materials like fresh ripe fruits, lustrous green leaves and disease free seeds etc to promote the livelihood in bay islands. Methodically, the contract farming of *Morinda citrifolia L.*, was launched on 17th October 2006 in collaboration with the HIL, Chennai the farmers and CARI, Port Blair. And successfully the agreement is completed its one year tenure with registration of more than 300 farmers and cultivating morinda in large scale. The Non Governmental organization and Self Help groups have taken part in this venture and motivated the farmers, which sequentially help in rehabilitating their livelihood. The environmental value of the medicinal plants lies in the fact that by growing as under story crops, associated species and intercrops, they complement to the growth and sustenance of trees thus conserving the forests. (Karkil *et al.*, 2003). The structure of root systems of morinda species contribute to soil stabilization and prevent erosion in the fragile soil. It can grow in any type of soil under low rainfall and moisture conditions thus assisting natural regenerations. There are enormous areas of land in India, including wasteland, shallow land, sea water inundation land on which mixed plantations involving other medicinal plants can be raised in different configurations of crop geometry.

Through Trade and enterprise development

The demand of *Morinda citrifolia L.* and its associated species is highly economical. According to the report of Centre for Research Planning and Action the demand for medicinal plants in India to meet both domestic and export market comprising of more than 162 species, is

expected to increase to about 15 to 16 % (Anonymous 2000 and Anonymous 2000a). *Morinda citrifolia* a medicinal plant with ecofriendly qualities with cultivation and management, therefore, can become highly remunerative both in financial and economic returns for the small scale growers. Based on CARI, Port Blair studies following results were obtained. The economic analysis of *Morinda* cultivation per acre basis was worked out. The standards procedure of cost benefit analysis were adopted. The BCR was worked out to be 11.9:1 without considering the opportunity cost. According to the estimation the second year onwards the maintenance cost shall be about Rs.25/- per plant per year. Noni plants start flowering in 8-10 months after planting. Commercial harvest starts from 20 to 24 months onwards. It yields 10kg/plant after 24 months. It is reported that noni plant is capable of giving yield upto 250-300 kg/tree year under better management cultivation after 7-8 years. A well grown tree will produce an average of 90-100 kg/tree. It is reported that productivity of the tree is upto 40-50 years. The harvest can be done more than 6-7 times in a year. The demand for noni plant is increasing day by day among the people as well as farmers in the Bay Islands due to the assured buy back arrangements with Health India Laboratories, Chennai, producing and marketing the healthy food supplement, Noni. In this sector, the essential raw materials of their food supplement, but also its collection, production, processing, packaging and transportation requires high labour input, which can create employment oppointments in place like Bay islands. Collection from wild, nursery raising, initial cultivation practices and primary processing are done manually and even at the secondary and tertiary levels, there are substantial labour requirements. Moreover, not only the medicinal and aromatic plant based industries expand job, oppointments but also enhancing traditional uses through value added processing which can increase cash earning to the local people. (Karki, 2000).

Through Domestication and Cultivation

Cultivation of medicinal plants especially and certified organic farming concept has greater scope in the region. The prospects and advantages of cultivating *Morinda citrifolia* L. include ease of their cooperation in the existing cropping systems due to its adaptability to a wide range of environmental conditions or its suitability to be grown in different eco-physical conditions. This plant tolerates high salinity, and in view of the above facts, this plant plays a important role in coastal stability, land reclamation and the protection of farms from salt

water spray and also sea water inundated agricultural lands were restored by this magical plant. (Singh *et. al.*, 2006). Cultivation of *Morinda sp.* a mixed, intercrop in agro and farm forestry conditions following a soil improving crop rotation is highly feasible livelihood enhancing activity. However, this will require an improved input and service delivery system include marketing and post harvest technologies. Morinda cultivation can be done as a business venture by a chin of small and micro enterprise based groups and individuals. In order to achieve the economy and a desired impact, the cultivation needs to be fully concentrated on selected pockets of the bay islands in an intensive manner.

Morinda Cultivation a Sustainable Livelihood Approach. (SLA)

Morinda citrifolia L., can be successfully utilized to develop sustainable livelihoods of the tsunami affected farmers as well as the local people of bay islands. This highly potential plant is quite suitable to all the conditions even where other hardy plants cannot survive. Sustainable Livelihood Framework (SLF) is a recent evolution in the international paradigms and it has been said to offer an opportunity to launch poverty reduction efforts by taking an all round view of the circumstances of the poor, as they themselves view them , rather than jumping to early conclusions and immediate proceeding to conduct isolated and input analysis of particular attributes.

Launching of Contract farming in Bay Islands is measure for increasing farmers' income

Keeping in view, for the betterment of the local farmers fighting to regain their economic stability after the disastrous tsunami and also after tremendous research done on Morinda to check its stability in sea water. An agreement was made between the farmers, Health India Laboratories, Chennai and Central Agricultural Research Institute, Port Blair and in support with the Administration, Port Blair. CARI has developed a Morinda Orchard and about 10-20,000 seedlings are produced for the selling purpose to the farmers. The HIL Company has assured a buy back arrangements at of Rs.10 per kg from the farmers of the islands which it is Rs.5/- per Kg in the mainland. If this sort of equitable bio-partnership arrangements or direct collaborations are made then it can develop fair and ethical commercialization of *Morinda citrifolia L.*

Stakeholder participation

Local people, who are tsunami affected farmers, have been completely motivated about the fruitful aspects of cultivating *Morinda citrifolia*. The NGOs and SHGs should consult and work with community based organizations and engage them into participatory process and their involvement in the very beginning is expected to enhance people's participation and provide benefit to a wide range of cultivators. In order to understand the complex market and marketing related issues, market- related information, scooping of problems and opportunities with good practice tag need to surveyed and studied to develop a marketable product portfolio. The outcome of these studies can be useful to plan equitable commercialization, identify potential small and micro enterprises, and assess available raw material resources and product mix.

Employment potential

The degree of dependence of rural people on Morinda based livelihoods is significant as it provides jobs to the poor people and much needed cash to the subsistence farmers, especially to the small scale cultivators, collectors, processors and traders. Cultivation and gathering of harvested fruits has a great employment potential. From this single fruiting plant, medicine, food supplement, essential oil and natural dyes can also be extracted which can be exploited by setting up micro enterprises for processing of the raw materials and the value addition locally. This would provide more employment to the local people.

Linkages with Research and Traditional Knowledge

In the context, as a part of the sustainable livelihood approach based intervention, the medicinal-plants resources and associated knowledge can be included as the inherent strengths of farming community in the bay islands can be built. This diverse and versatile resource can be made to provide local people with greater incentives by investing in livelihood projects. There is potential to increase current benefits to many folds provided the livelihood enhancing MAP- based activities could be built – on the strengths of the local people as well as aborigines such as rich bio-resource, indigenous and traditional knowledge and robust social organizations. The decentralized governance of the resources could be made possible through enhanced people's participation and greater government support. Research institutions could

help to define key parameters like better cultivation, production, and ways to integrate ex-situ and in-situ conservation and overall natural resource management that would enhance sustainable livelihood. The vast potential of harnessing traditional knowledge and research activities can be mobilized through improved coordination of activities, multiple links need to be established with collectors, growers, traders, processors and consumers at different levels in a value chain.

Livelihood Supporting Activities

The collectors and growers should be provided with credit and storage facilities to avoid distress sale. Fixing minimum floor prices also works as a strong incentive for collectors and growers as they can rest assured for a certain level of income through sales of their produce.

Strengths and Benefits of *Morinda citrifolia*

In this context, this sector has much to offer, not just in the way of raising season income through collection and cultivation activities, but also being an integral component of forest resource management. *Morinda citrifolia* L., biodiversity assessments, inventorying and management and establishment of nursery development, plantation management and post harvest activities can provide employment opportunities for improving the livelihood. *Morinda* sp. acts as a coastal green shield and should be raised in tsunami affected lands on a priority basis and gradually in all the islands as a means of coastal protection from natural calamities. It is envisaged that, immense awareness and efforts if given it would serve the dual purpose of protecting the coast and also adding aesthetic values with its huge magnitude. It is concluded that, this morinda plant will give direct benefits in terms of pecuniary returns to the morinda cultivators and also will be revenue to the regime.

Conclusion

Various research and development actions have been attempted by Central Agricultural Research Institute, Port Blair for increasing the sustainable livelihood of Andaman farmers.

Creating livelihood through *Morinda* is another efforts. This valuable plant species is far reaching proposal especially for poor rural communities, who are often highly dependent on

their land, health and economic benefits based on this traditional and commercial, collection and use. Since development comprises integrated development of people's health, protection of environment, and provision of livelihood security to the poor, industry and private sector should shoulder this social responsibility to solve their both short and long term problems in the process. It is hoped that national and international conferences such as the current one can be a platform from which such recommendations and ideas can be generated that can influence the researchers those who have great role to play and sensitize the private sector .

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Peptide and Mineral profile of *Morinda citrifolia* fruits and leaves

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Abstract

Morinda citrifolia L., (noni) has a long history related to medical uses in South East Asian countries. In order to obtain better understanding of the medicinal characteristics of the noni fruits and leaves, the peptide profile and the mineral compositions of the raw juice extracted from *M. citrifolia* fruits and leaves were determined. *Morinda citrifolia* fruits and leaves were subjected to dry ashing for the preparation of acid-mineral extract for micronutrients and macronutrients analysis by atomic absorption spectrophotometer. For analysis of peptide profile the water extraction of the *M. citrifolia* fruits and leaves were done and the extract was used for HPLC analysis. The peptide profile of the *Morinda citrifolia* fruits and leaves were studied by using high performance liquid chromatography (HPLC). The concentration of micro and macro mineral of *M. citrifolia* leaves was found to be more than fruits. The HPLC analysis of the peptide profile of the *M. citrifolia* revealed the following peptide in various concentration such as Gly-Tyr, val-Tyr-Val, Meth-Enkephalin and Leu- Enkephalin. Overall, the peptide concentration of the leaf extract was found to be more than the fruit extract. High level of peptide Val-Tyr-Val was found in leaf extract (15.856 ppm) while in fruit the peptide Leu-enkephalin was maximum (3.697 ppm). The peptide analysis of the *M. citrifolia* may be useful in studying various alkaloids present in the fruits and leaves and will be of use in studying the effect of *Morinda* extract in immune system regulation.

Introduction

Over the last decade, a large number of people have become interested in the medicinal uses of noni juice, made from the fruit of the Indian mulberry (*Morinda citrifolia* L.) of the South

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Pacific Islands of Tahiti, and more recently from Hawaii. *Morinda citrifolia* has been used in folk remedies by Polynesians for over 2000 years, and is reported to have a broad range of therapeutic effects, including antibacterial, antiviral, antifungal, antitumor, antihelminthic, analgesic, hypotensive, anti-inflammatory, and immune enhancing effects (Singh et.al., 1984, Whistler, 1985). It has attained significant economic importance worldwide in recent years through a variety of health and cosmetic products made from leaves and fruits. These include fruit juice as well as powders made from the fruit or leaves. However, scientific evidence or the research findings are limited. The history of published medical research on noni phytochemicals numbers only around a total of 120 reports which began appearing in the 1950s. Since 2000, about 105 publications on noni have been published in medical literature, defining a relatively young research field. Nearly all noni research is at a preliminary stage, still in the laboratory as in vitro or basic animal experiments. Despite the large market for juice products and research developments, the nutrient and phytochemical profiles of noni have not been extensively studied.

Morinda citrifolia L., has been documented to contain a mixture of anthraquinones, organic acids, xeronine, several vitamins (such as beta-carotene, niacin, riboflavin, thiamine), some minerals, iron and calcium (Duke, 1992, Levand & Larson , 1979, Moorthy & Reddy, 1970). The potassium content is similar to that in tomato juice and orange juice. Some of the beneficial constituents of Noni include various terpene compounds, caproic and caprylic acids, vitamin C and alkaloids. However, Noni is most famous for the presence of an alkaloid proxeronine, which is believed to be a precursor to xeronine (Heinicke, 1985).

In order to obtain better understanding of the medicinal characteristics of the noni fruits and leaves, the biochemical profile and the mineral compositions of the fruits and leaves of the *M. citrifolia* is very important. The present study was conducted to study the biochemical profile and the mineral profile of the fruit and leaf of *M. citrifolia* plants present in different locality of these islands. The extent and pattern of mineral deficiencies/imbalance in plants vary in different agro-climatic condition as available mineral content in the green vegetation depend on physical and chemical property of soil, soil erosion, cropping pattern, fertilizer/chemical application, species and genetic difference of plant, stage of maturity, presence of other mineral, etc. (McDowell et al., 1993). Studies on soil-plant relationship in respect of minerals are important and to understand the mineral uptake and the contents of the fruits and leaves the soil from the respective areas were also collected for micro and macro mineral analysis.

Materials and Methods

An extensive survey was made in South Andaman and as per the location of the tree various accessions were given and soil samples were collected by using maun cover (7 cm & 60 cm length) auger. The soil samples were air dried, powdered with wooden mallet and sieved through a 2 mm sieve. The sieved samples (< 2 mm) were analyzed for potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) content as suggested by Page et al., (1982).

The fruit qualitative parameters were determined by the method as described by Ranganna (1986). The TSS of the samples was estimated by hand refractometer. The fruit size and general appearance were estimated by metroglyph method and mature fruits of different accessions were washed and pulp was taken out with the help of knife and dried in an air circulatory tray drier at 60 °C for 48 h. Dried pieces were cooled and powdered in a heavy duty grinder. For analysis, the powder was sieved using a 60 mesh sieve and packed in 200 gauge high density polythene bags (Chavan et al., 1995). The quantitative estimation of minerals in fruits and leaves were carried out by using an atomic absorption spectrophotometer. The dry ashing method was followed for estimation of micro and macro minerals immature dried leaves (Jones et al., 1969).

Peptide profile by HPLC : Raw juice extracted from *M. citrifolia* fruits and leaves were prepared for estimation of the peptide profile. The peptide profile of the *Morinda citrifolia* fruits and leaves water extract were studied by using high performance liquid chromatography (HPLC). The water extract of *M. citrifolia* fruits and leaves were prepared and filtered through 0.45 µ membrane filter. The extract was run through HPLC column C-18 with mobile phase water and acetonitrile in 0.1% trifluoroacetic acid (TFA) in gradient condition. The flow rate of the column was adjusted at 1 ml/min. The standard peptide mixtures were run through the column. The eluent A of mobile phase was a 0.1% by weight aqueous solution of trifluoroacetic acid (TFA) and eluent B was acetonitrile containing 0.1% by weight TFA. A fifty minute linear gradient from 0 to 30% B was run at a flow rate of 1 ml/min.

Mobile phase :

A – Water with 0.1 % TFA

B – Acetonitrile with 0.1 %TFA

Detector : UV- 210 nm

Column : Luna 5 u C-18 (2) (4.6X 250 mm)

Gradient :

Time (min)	B %
0.01	2
30	30
30.1	2
50	2

Results and Discussion

Physico-chemical properties of fruits :

The total soluble solids (TSS) of the fruit were higher in JGH-5 followed by HD-6 while minimum was in accession SPG-2. Maximum ascorbic acid content was recorded in HD-6, followed by PBAY-7 (Table 1). The ascorbic acid ranged among all the accessions from 92.30 to 139.87 mg/100g. The fruit and juice weight recorded maximum in HD-6 followed by PBAY-7 while minimum fruit weight was recorded in SPG-2. The minimum juice % was recorded in JGH-5. In overall quality of the fruit HD-6 was found to be the best among the various accessions. In the present study the various qualitative parameters are different from each other; this might be attributed to tropical humid and unique climatic conditions of Andaman & Nicobar Islands.

Minerals in fruits and leaves :

As indicated in table 2 leaf and fruit powder of all the accessions was found quite rich in minerals like K, Ca, Mg, Fe, Cu and Mn. Maximum K was found in MEM-3 as 1182 ppm and minimum in SPG-2 (101 ppm) while on an average the potassium content was higher in leaf as 1390 ppm where as 935.9 ppm was recorded in fruit. Calcium, magnesium and iron content were recorded highest in HD-6 accession, and minimum quantities of calcium and iron were recorded in accession FF-8 while magnesium content was lowest in WAND-4. The copper and manganese content ranged from 2.13 to 28.5 ppm and 3.98-4.75 ppm respectively. However, the maximum copper content was recorded in WAND-4 as 28.58 ppm while minimum in SPG-2 as 2.13 ppm. In all

accession the copper was at higher side in fruits (18.65 ppm) whereas in leaf it was recorded minimum as 6.7 ppm. However, manganese was higher in leaf as 23.4 ppm while in fruits it was just recorded as 4.21 ppm.

Peptide profile of leaf and fruits :

The water extract of fruit and leaves were run in HPLC; C-18 column to study the peptide profile. The following di-peptide, tri-peptide and pentapeptide profile were obtained such as Ly-Tyr, Val-Tyr-Val, Meth-Enkephalin, Leu-Enkephalin and Angiotensin. The concentration of each peptide is presented in table 3. High level of tri-peptide Val-Tyr-Val was found in leaf extract (15.856 ppm). In the fruit the level of pentapeptide Leu-Enkephalin (3.697 ppm) was found to be more. An enkephalin is a pentapeptide ending with either leucine ("leu") (Tyr-Gly-Gly-Phe-Leu) or methionine ("met") (Tyr-Gly-Gly-Phe-Met). Both are a product of the proenkephalin gene. Meth-Enkephalin is an endogenous opioid neurotransmitter, neuromodulator, also enhances antibody response and immune system function and also function as growth factor (Beck et.al., 2001). Enkephalins play many roles in regulating pain. The peptide analysis of the *M. citrifolia* may be useful in studying various alkaloids present in the fruits and leaves and will be of use in studying the effect of Morinda extract in immune system regulation. Overall, the peptide concentration of the leaf extract was found to be more than the fruit extract except the Ly-Tyr which is more in fruit than in leaf.

Physico-chemical properties of soil :

The physico-chemical properties of the soils revealed that the soils are of acidic in nature with pH varied from 4.6-6.1. The average organic carbon content of all the soils was recorded to be greater than 0.75 while the soil moisture varied from 18-23%. The mineral profile of the soil in general is reported to be more than the normal level in almost all the soil. Except the concentration of sodium and zinc the level of all other minerals were found to be in normal range (Table 4). The level of Zn was very low in all the soils except the soil of accession WAND-4 (17.82 ppm) which was recorded to be very high. Very high level of mineral such as Ca, Mg and Fe was detected in almost all the soil. The maximum level of K was detected in soil of accession SPG-2 (151.1 ppm) while the lowest level was detected in soil of accession PBAY-7 (29.50 ppm). Overall, the level of all the micro and macro mineral profile of the soil was normal except for few minerals such as Na and Zn.

Nutrient analyses for a major brand of noni juice (Tahitian Noni Juice™, TNJ) were published in 2002 by the Scientific Committee on Food of the European Commission on Health and Consumer Protection (ECHCP). The report suggest that the whole fruit powder has excellent level of carbohydrates and dietary fiber, protein (12% DRI), low in fat (4% DRI).The macro nutrients is present in sparse amount. The pulp of the fruit is reported to contain high level of Vit.C, niacin (Vit. B3), Fe while K, Vit.A, Ca and Na present in moderate amount. In the present study, the similar trend of micro and macro nutrients was obtained. The high level of ascorbic acid was obtained in almost all the accession. The average value was recorded as 113 mg /100g. Varieties in nutrient composition in leaf and fruit from one accession to another might be attributed to tropical hot and humid climatic condition prevailing in Andaman & Nicobar islands.

Table1: Comparison of Ascorbic acid content, TSS and Juice percentage of *Morinda citrifolia* fruits collected from different accessions (in ppm)

Accession	Fruit wt. (g)	Ascorbic acid (mg/100g)	TSS (°brix)	Juice %
GAH-1	78.44	111.80	8.0	38.66
SPG-2	70.35	92.30	6.0	32.46
MEM-3	115.70	106.60	8.6	33.11
WAND-4		97.93	7.0	38.14
JGH-5	127.55	107.47	9.0	29.92
HD-6	163.99	139.87	8.7	60.25
PBAY-7	134.50	132.60	7.0	38.29

Table 2 : Nutrient analysis in *Morinda citrifolia* fruits collected from different accessions (in ppm)

Accession	K	Ca	Mg	Fe	Cu	Mn
GAH-1	1174	52.14	167.53	29.13	27.13	4.15
SPG-2	101	45.73	162.54	20.98	2.13	4.08
MEM-3	1182	50.75	168.58	30.51	22.45	4.05
WAND-4	968	45.51	162.04	25.51	28.58	4.18
JGH-5	1175	46.25	165.00	25.19	25.20	4.06
HD-6	1226	58.89	196.64	42.44	2.44	4.75
PBAY-7	1158	48.51	185.13	35.41	25.42	4.09
FF-8	1048	42.25	171.54	29.53	22.41	3.98
Fruit Average	935.9	49.12	173.77	30.21	18.65	4.21
Leaf Average.	1390	60.08	533	44	6.7	23.4

Table 3: Peptide profile of the *Morinda citrifolia* fruit and leaf (in ppm)

Extract	Ly-Tyr	Val-Tyr-Val	Meth-Enkephalin	Leu-enkephalin
Morinda fruit	1.04	0.114	0.865	3.697
Morinda leaf	0.705	15.856	4.135	1.307

Table 4: Major and micronutrient analysis in soil samples collected from different accessions of *Morinda citrifolia* growing areas (in ppm)

Accession	K	Na	Ca	Mg	Fe	Cu	Mn	Zn
GAH-1	98.00	55.30	6198.05	924.54	42.99	2.21	43.04	0.24
SPG-2	151.10	113.10	8409.36	899.82	18.48	0.30	82.88	0.59
MEM-3	52.20	24.80	5238.10	835.54	19.47	0.19	3.12	0.15
WAND-4	112.30	102.10	5158.25	953.10	89.06	2.61	77.04	17.82
JGH-5	72.00	48.10	3388.11	922.15	24.84	3.86	56.13	1.28
HD-6	66.30	49.30	6238.30	913.04	40.98	2.13	62.30	0.98
PBAY-7	29.50	23.50	9096.99	830.35	10.54	2.87	54.85	2.36
FF-8	55.70	28.00	1924.59	818.11	63.55	1.48	34.88	1.04
Avg.	81.77	58.08	5667.333	886.78	40.951	1.97	50.024	4.24
Range	29.5-151.1	23.5-113.1	1924.59-9096.99	818.11-953.1	10.54-89.06	0.19-3.86	3.12-82.88	0.15-17.82

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A Study Involving the Production of *Morinda citrifolia* L. (Noni) by Small Farmers in A & N Islands, India

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Abstract

Contract farming has been in extreme for many years as a means of organizing the commercial agricultural production of both large and small scale farmers. This study explains the steps taken by the Central Agricultural Research Institute, Port Blair in Andaman & Nicobar Islands, India to help small farmers link up with reliable markets to produce and market high value medicinal fruit of Noni.

The scenario cropping up after tsunami turned the land unsuitable and people non-plussed. Strategies to address the burning issue and to lure them towards farming was challenging to the researchers and extension personnel. There was dire need of providing a suitable technology having zero management which could fetch a decent earning of Rs. 6000 to 7000 per month as livelihood support to local farmers. The scientific team of CARI after rigorous efforts came up with a technological option christened as “Morinda citrifolia” (Noni), a wonder plant, best suiting to the location and nature of the displaced farmers of these islands. The production techniques and benefits were disseminated throughout the islands through Group approach an innovative extension methodology wherein numerous awareness camp, field visit, field day, interactive lectures, video shows, TV, Radio Talks, personal contact and Peer Groups by the institute ToT wing i.e. KVK and ATIC was conducted. The highlight of the technology was the buy back arrangement i.e. Public – Private - Partnership came up, which the first of its kind in the Island and also in the history of CARI (ICAR) involving a Tripartite agreement signed with

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*Health India Ltd. Chennai. Thus **the Chain from Research to Extension to Farmer to Market was accomplished** and an example was set by the Institute which has resulted in horizontal expansion of the technology in cluster of villages of South and Little Andaman.*

Introduction

Agriculture the only support system of farming in the Bay Island is prevalent over 140 years or so old which is spread over 8249 sq.km in 52,000 ha of land to cater to the need and feed the stomach of 3.5 lakhs people (Anonymous 2006). The scenario cropping up after tsunami turned the land unsuitable and people non-pulsed. Strategies to address the burning issue and to lure the young and middle age group (comprising of 40 percent) towards farming, who are found to be moving away to township in search of other vocations was challenging for both the researchers and the extension personnel. The dire necessity to provide a suitable zero management technological intervention which could fetch a decent earning of Rs. 6000-7000 per month per individual as livelihood support was the call of the day. The scientific team of Central Agricultural Research Institute (CARI) after rigorous effort came up with the technological option *Morinda citrifolia L* alias Noni (Singh, 2006) best suiting to the location and nature of the displaced farmers of these Islands with added advantage of buy back mechanism i.e. contract farming. After the launching of contract farming by CARI in association with Health India Laboratories, Chennai, on 17th October, 2006 (Anonyms, 2006) there has been mushrooming of Morinda cultivation in around South and Little Andaman which is practiced in backyard, under coconut plantation, waste land and also as solo crop. The Tripartite agreement offering 10 years business with Rs. 10 per kg. of fruit at the door step has given momentum to the cultivation of Morinda and empowerment in the form of entrepreneur development to small farmers. The flexibility, simplicity and down to earth agreement has made history in the Island.

It is right time to known as to how this technology took a fast stride leaving behind all the other lucrative enterprises. A micro level study with an objective to know the participation level, knowledge gain, adoption and preference of the respondents was carried out, beside the spread of the technology was also taken into account.

Material and Methods

An Ex-post facto study was conducted consisting of 120 randomly selected sample from 6 village clusters representing four from South and two from Little Andaman. Knowledge gain was measured through before and after design by administering questions derived from difficulty and discriminatory indexes. Adoption Index, preference of respondents and spread of technology was also studied in a participatory mode. Whole sample was considered to know the participation level of the respondents.

Results and Discussion

Group approach an innovative extension methodology was used to disseminate the know how and do how in various cluster of villages. To know the impact of the approach, specific socio-psychological features were considered. The finding of the study is manifested below for better understanding.

1. The extent of Participation of the Respondents

It is evident from the table 1 that under the programme to popularise Morinda cultivation in the Island, 21 training programmes (both on and off campus), awareness campaign (05), Kisan Gosti (04), exposure visit to CARI (07) and launching of contract farming (01) were conducted during the period. Overall participation of the respondents accounted for 707 men and 2795 women totalling to 3502 reflecting a ration of 1:3.30. The scenario of low participation of men is reflected in all the programmes. The reason being the implementation of cash for work programme by the NGO's after tsunami wherein mostly all the male members of the house in the village cluster attended to earn money for their livelihood, whereas the women participated whole heartedly in the livelihood programme organised by CARI with a sole idea of earning a permanent livelihood for thier family after cropping up of such adverse situation. The over whelming response of women folk may make them the integral part in promotion of Morinda cultivation in these islands.

Table 1. Distribution of respondent as per their participation

Particulars	Respondents			Ratio
	Men	Women	Total	
Training On & Off Campus (21)	236	709	945	1: 3.00
Awareness Campaign (05)	195	1060	1255	1: 5.50
Kisan Ghosti (04)	74	351	425	1: 4.74
Exposure visit to CARI (07)	87	208	295	1: 2.39
Launching of Contract Farming (01)	115	467	582	1:4.06
Total	707	2795	3502	1: 3.30

2. The Extent of Knowledge Gain of the Respondents

The pre and post exposure knowledge levels of the trainees were assessed in order to find out the knowledge gain due to the training. It could be inferred from table 2 that before (pre) the training 91 percent of the respondents were found to have low level of knowledge on areas viz. Morinda crop, planting technique, medicinal value of fruits and leaves, harvesting stage, marketability etc. Only 9 percent represented to possess medium level of knowledge and nil in high level category. But after the training the respondents were found to be maximum in medium level category (71%) followed by high (17.5%) and then low (11.5%). The reason for the above gain in the knowledge by the respondents might be due to the fact that majority were enthusiastic and more interested in subject taught. To generate assured self employment the members would have paid more attention leading to more gain in knowledge. Likewise the leaflets provided in vernacular language (Hindi) would have reinforced on the knowledge imparted. The finding is in line with the findings of Ahmed (2006).

Table 2. Distribution of respondent according to their knowledge level

(n=120)

Category	Knowledge Level	
	Before Training	After Training
Low	109 (91.00)	14 (11.50)
Medium	11 (9.00)	85 (71.00)
High	-	21 (17.50)
Total	120 (100)	120 (100)

Figure in parenthesis denotes percentage

3. The Extend of Adoption of the Technology by the Respondents

The extent of adoption of the identified five technologies like selection of seedlings, pitting and planting, manure application, harvesting of fruits and finally grading and packing were assessed. From the table 3 it can be understood that there was highest level of 91.66 percent adoption in case of selection of seedlings, followed by pitting and planting (85%), manure application (60%), harvesting of fruits (22.50%), and very low percentage of 9.16 in the case of grading and packing.

This trend may be mainly due to urge or desire of the individual to start the work in right spirit to fetch a better return later on. That is the reason wherein the seedling selection, pitting and planting has shown high rate of adoption and other technologies like manuring, harvesting of fruits, grading and packing though important has been kept behind by the farmer. He would have thought to learn first the establishment technology which is more needed and later on imbibe others to as per the crop stages.

Table 3. Distribution of respondent according to their adoption

(n=120)

Sl.No.	Technology	Adoption
1.	Selection of Seedlings	110 (91.66)
2.	Pitting & Planting	102 (85.00)
3.	Manure	72 (60.00)
4.	Harvesting of Fruits	27 (22.50)
5.	Grading & Packing	11 (9.16)

Figure in parenthesis denotes percentage

4. Preference Matrix Ranking of *Morinda citrifolia L.* by Respondents

Respondents preference taken in participatory mode through matrix in range of 1 to 5 with 11 parameters is presented in table 4.

The preference mode of the respondents ranged from 3 to 5 which is a good indicator for the crop being accepted by the displaced small farmers of this Islands. Good yield, assured profitability, Insect pest tolerance, market preference and livelihood security i.e. 5 parameters out of 11 were rated high followed by next five i.e. seedling availability in time, risk of crop failure, immature fruit size at harvest, less labour requirement and shelf life characters. All these parameters in totality lead to the preference and also the acceptance of the crop in toto. Water requirement was felt to be slightly more because after transplanting of the crop here was a long dry spell and the crop had to be saved against natural calamity.

Overall,-- the preference of the respondents derived through matrix ranking was rated to be good and highly appreciable.

Table 4. Preference Matrix Ranking of Respondents Practicing Morinda Cultivation.

Parameters	Matrix Ranking (1-5)
Seedling Availability	**** (4)
Water requirement	*** (3)
Risk of Crop Failure	**** (4)
Fruit Size (at harvest)	**** (4)
Yield	***** (5)
Profitability	***** (5)
Insect Pest Tolerance	***** (5)
Labour Requirement	**** (4)
Shelf Life	**** (4)
Market Preference	***** (5)
Livelihood Security	***** (5)

5. Horizontal Spread of the Technology

Any technology whether of agriculture or allied field is regarded to be the best when it has got its adoption by the target group and seeing its economic importance it spreads horizontally from one to another cluster of villages. Here we are trying to make you understand by means of flow chart (fig. 1) the horizontal spread of the technology from one village to many villages in South and Little Andaman. The area expansion is seen around 100 acres, with 225 target clientele within a short span of one year which was only possible due to the front line broad basing of extension methodology and setting of a chain from Research to extension to farmer to market involving farmers, farm women, SHGs', Scientists, change agents, extension functionaries and peer groups in the process of accomplishment.

Conclusion

For any technology to be a successful one it should be flanked with four pillars i.e. the technology provider, input provider, favourable policy / governance and finally the most

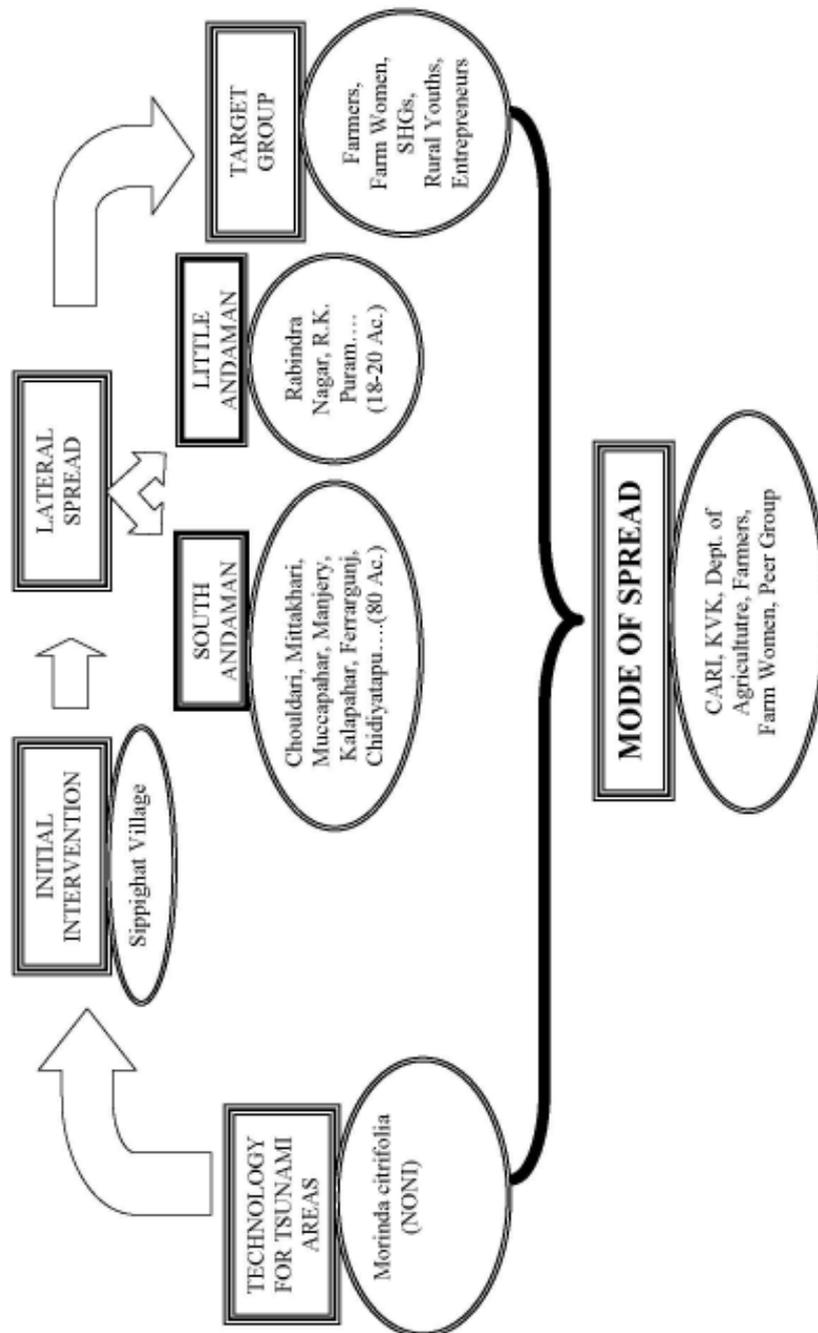
important the marketing. It is proud to say that the change in paradigm of extension approach from Research – Extension – Farmers (REF) to Research – Extension – Farmer – Market (REFM) has been set in these islands by the only research Institute of ICAR i.e. Central Agricultural Research Institute, Port Blair by providing a platform of contract farming with Health India Laboratories, Chennai for *Morinda citrifolia* L. (NONI) the first of its kind in the history of Islands and also ICAR for the small farmers of these emerald Islands.

To conclude the contract farming on Noni a befitting example of an innovative extension approach has brought the farmers very close to the scientist and vice versa. The venture has been appreciated by A & N Administration and looked upon to be replicated by the development department in the field of high value agriculture with the booming tourism in these Islands.

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Fig 1. Flow Chart depicting Horizontal spread of the Technology in the Island (2006-07).



Economic Appraisal of *Morinda citrifolia* L. (Noni) Cultivation in Bay Islands

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Abstract

Morinda citrifolia var. *citrifolia*, commonly known as Noni in India and also as the Indian Mulberry is one of the important plants of Rubiaceae family. Noni's broad proliferation gives testimony to its value to traditional cultures. In Andaman and Nicobar Islands, it is widely found through out the coastal region and also found as wild tree along the fences and the roadsides due to its wide adaptability to hardy climatic conditions. The most important fact is that tribes of these islands are known to consume raw fruits with common salt as well as cook as vegetable. After Tsunami disaster, it has been observed that *Morinda* is one among the plants survived in salt affected areas. Further studies conducted by CARI shows that *Morinda* plantation could be an option for rehabilitating the livelihood of Tsunami affected farmers. *Morinda* cultivation assures the regular income and employment security. This plant is having many nutritional properties and economic importance for coastal areas, since whole plant i.e., leaf, stem, root and fruits can be economically utilized. it has to be evaluated in terms of costs and benefits from its cultivation. In light of above, this paper presents the economics of cultivation of *Morinda* in farmers' fields in Bay Islands. This plant starts giving economic yield from third year onward. It was observed that of five years old plantation gives an gross income of Rs. 6,25,000 with net income of Rs. 3,56,981/ ha. This indicates the economic viability of *Morinda* cultivation in the Bay Islands. Further, maintenance cost is minimal and has got long terms sustainable returns.

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Introduction

Indian Noni plant botanically known as *Morinda citrifolia* L. belongs to the family Rubiaceae. It is commercially known as Noni, It is also known as Indian Mulberry, Cheeze fruit, Yellow fruit, Pain killer and Nono. It is a large shrub or a small tree, native to Southeast Asia but has been extensively spread throughout India and into the Pacific islands as far as the Hawaiian Islands. In Andaman and Nicobar Islands, it widely found through out the coastal region and also found growing wild along the fences and the roadside. Two main varieties i.e. *Morinda citrifolia* var. *citrifolia* and *Morinda citrifolia* var. *bracteata* are both equally important and are available in plenty in the A&N Islands. Due to its adaptability to wide range of environmental climatic conditions, the noni plant grows even in infertile, acidic and alkaline soils and also prefers to grow even in the dry and wet areas. The tropical humid climate is very much suitable for the cultivation of *Morinda citrifolia* L. (Singh et al., 2005). The species is best known to tolerate salty soils and salt spray. Due to its hardiness or versatile nature it is found growing near road side (Location -11°37'03.8"; 92°42'30.2"), near sewage drain (11°40'6.3";92°44'15.9"), under shaded condition (11°40'13.5";92°43'56.2"), in hill top(11°35'50.7'; 92°43'56.2"), near sea shore (11°35'37.6"; 92°36'38.1"), in sea inundated lands (11°36'42.6"; 92°40'47.3"), in jungle areas (11°40'27.8"; 92°43'36.8") and in various other locations like Ross Island, which was erstwhile capital of Port Blair during the reign of British, where *Morinda* tree was found to be growing in tree trunks, in old damaged buildings, in symbiotic association with *Ficus* plants etc. located in tree trunks.

Table 1: Land use pattern of Andaman & Nicobar Islands

S.No.	Particulars	Andaman & Nicobar Islands	Little Andaman (Hut Bay)
1.	Total Geographical area (ha.)	824900	73157
2.	Forest (ha.)	750124	70385
3.	Area under non agriculture use (ha.)	6904	94
4.	Barren and uncultivated land (ha.)	6411	441
5.	Land under trees and other area (ha.)	3613	383
6.	pasture and grazing land (ha.)	5145	546
7.	Cultivable waste (ha.)	5428	358
8.	Fallow land (ha.)	3158	-
9.	Net sown area (ha.)	17100	950

It is observed from the above table that about 80 percent of the area is under forest and very limited area is left for cultivation and other purposes for entire Islands. Similar is the case of Little Andaman. This has put forth the challenges before the researchers and policy makers to optimal utilization of the existing land resources.

Methodology

The present investigation was carried out in bay Islands based on the data collected from 25 farmers (Table 2) on cost incurred and benefits accrued in the cultivation of Morinda. The standard procedure (Cost A, Cost B, Cost C and Net Benefit Ratio) was adopted to carry out the entire analysis. The data on cost and benefits were collected from Morinda growers directly for two years of planting and extrapolated for five years of Morinda cultivation. The land rent and interest on working capital were worked out at bank rate of lending credits. These morinda cultivators are the member of Shanti Mata Self Help Group. This SHG was started functioning during 2005-06 with the monthly instalment of Rs. 50/-. The amount

collected as the subscription is being used as the credit among the members. Till September 2007 the progress of the group was found to be good. In general morinda growers possessed limited land (2.08 ha. per family).

Table 2: Classification of respondents

Category of farmer	Number of farmer	No. of distributed seedlings	Land holding size(ha.)
Small	6	1100	0.96
Medium	15	3200	1.58
Large	4	500	5.25
Total	25	4800	2.08

Results and Discussion

Morinda plants starts flowering after 8 to 10 months of planting to get proper growth and development of plant hence, it is suggested to remove initial flowers up to at least 2 years. Commercial harvesting of the fruits will start after two years of planting. Initially yield will be about 10 kg / plant per year and it will gradually increase to 10 to 30 kg / plant per year (Singh et al, 2005). The mature tree had produced 250 to 300 kg per tree per annum as various studies reported. The researchers have pointed out that Morinda once planted and properly managed will stand for 40 to 50 years. Therefore, it is important to know the economics especially in tropical climatic condition particularly Andaman and Nicobar Islands, Tsunami affected areas

Cost Streams

The cost streams was worked out based on the standard procedure i.e. Cost A, Cost B and Cost C. Cost A includes variable expenses on land preparation, Planting materials, labours, manure application, irrigation, plant protection and other cultural operation. The interest

on working capital at the rate of 10 percent and depreciation at the rate of 12 percent was also taken in to account in the Cost A. The Cost B includes rent on land and total Cost under A. The Cost C includes imputed value of family labour. Hence Cost C is also called Gross Cost (Table 3.)

Benefit Streams

The direct benefit from the sale of Morinda fruits only was taken into account while calculating the gross benefits. On an average the yield of Morinda was taken 20 kg per tree per year and price of raw fruits @ Rs. 10/ kg of fruits. Though the studies conducted at CARI, Garacharma, Port Blair Research farm has noticed 28 kg/ plant after two year of plantation. The entire costs and benefits incurred for five years were worked out and presented in Table 3.

Economics of Morinda Cultivation

The Cost A including variable expenses, interest on working capital and fixed capital was worked out to be Rs. 13956 /-. The Cost B includes Cost A and rent on land and worked out to be Rs. 25000/- for five years. The Cost C which is known to be gross cost including input value of family labour was Rs. 268019/- per ha for five years. The gross benefits worked out to be Rs. 625000/- per ha. and net benefits were Rs. 356981/-. This shows that Morinda cultivation is highly economical proposition for this island particularly tsunami affected areas. However, the family labour income was taken into account in the analysis which is expected to be contributed by the family members. This money directly goes to the family member and further will increase the net return (Rs. 416981) of the cultivation. Thus, net return per year worked out to be Rs. 71396/- and per month was Rs. 5950/-. Further more, the waste and salt affected land optimally can be put for production purposes which will add income to the islands economy and will result in improvement of socio-economic status of island people.

Table 3: Cost of cultivation of *Morinda citrifolia L.*

S.No.	Items of expenditure	Cost (Rs./ha.)	Percent to Total
	Cost A =		
1	Land Preparation	2000.00	0.75
2	Digging of pits (@ Rs. 10/- Pit)	6250.00	2.33
3	Planting material (@Rs. 10/- sapling)	6250.00	2.33
4	Gap filling (25% causality)	1563.00	0.58
5	Labour exp. for planting sapling	1500.00	0.56
6	Bio fertilizer and manuring	5000.00	1.87
7	Intercultural operations	8000.00	2.98
8	Irrigation	8000.00	2.98
9	Plant protection	8000.00	2.98
10	Training and pruning	3000.00	1.12
11	Harvesting	50000.00	29.85
12	Transport and handling of produce	10000.00	3.73
13	Interest on working capital	13956.00	5.21
14	Miscellaneous expenses	4500.00	1.68
	Sub total	128019.00	58.96
	Rent on land*	25000.00	18.66
	Sub total	153019.00	77.61
	a. Input value of family labour	60000.00	22.39
	Cost C= Cost B+ (a)=Gross Cost	268019.00	100.00
	Price/ Kg of Morinda fruit	10.00	
	Gross income (up to 5 years)	625000.00	
	Net Income	356981.00	
	Net Income without consideration of family labour	416981.00	
	Net returns per year	71396.00	
	Net return per month	5950.00	

The economics of morinda cultivation for long term sustainability has been worked out by assuming the project life for 12 years. It was found that at 10 percent discount rate the BCR was 14.47 without considering the opportunity cost. Even if coconut plantation which competitive crop, included in the analysis and assigned opportunity cost the BCR was 8.33 which is also quite high. Therefore, it can be inferred from the table 4 that morinda cultivation is highly economical proposition for salt affected areas.

Table 4: Economic Appraisal of Morinda Cultivation

Year	Total Cost Rs.	Total Return Rs.	TC+ Opportunity Cost Rs.	Discounted Cost Rs.	Discounted Returns Rs.
1	16970	0	16970	13054	0
2	7900	0	7900	4675	0
3	9700	34000	9700	44151	15476
4	10900	68000	10900	3816	23809
5	10800	102000	10800	2909	27472
6	10900	136000	10900	2258	28176
7	12200	612000	28450	1944	97532
8	11800	255000	28050	1447	31260
9	13400	306000	29650	1264	28856
10	14000	340000	30250	1016	24663
11	13500	408000	29750	7538	22766
12	13500	408000	29750	580	17512
Total	145570	2669000	243070	38130	317521
BCR with Opportunity Cost at 10% = 8.33			BCR without opportunity cost at 10% = 14.47		

Conclusion

Since this plant tolerates high salinity, the farmers of the coastal regions may be advised to take up this plantation on large scale and also in the tsunami affected land. In this way large tsunami-affected areas can be rehabilitated by growing this miracle plant. It is anticipated that the article will bring awareness among the growers, layman and private investors in the relevant areas regarding the nutritional, medicinal and economic importance of this underutilized tree. Further, it will guide the policy maker to draft proper land use planning.

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Noni – (*Morinda citrifolia L.*) Organic Farming System and Viable Models

MA. Palanichame*

Abstract

*The required components of a true organic farming system as expected by a certifying body and or by IFOAM are dealt in detail. Noni (*Morinda citrifolia L.*) is getting importance for human health and wellness. Improved productivity associated with quality is the main objective. To attain improved productivity and quality, organic farming is recommended. The main components of organic farming are mulching, intercropping, integrated pest management, integrated irrigation management, composting and harvest and post harvest handling in a natural way. Preparation of month wise calendar of farm operations for all the 12 months in a year for another 36 months is the first step. The 36 months are taken because the Noni plant starts yielding from 3rd year onwards.*

Hazard Analysis Critical Control Points (HACCP) are also taken into consideration.

Introduction

Morinda citrifolia L. – the Indian Noni, has resurfaced in India – thanks to the ever searching mind of Holi Noni Dr.P.I. Peter. Noni is a promising crop and it must succeed as an orchard crop.

Special Features

Morinda citrifolia L. a dwarf, perennial shrub, capable of yielding up to 40-50 years, growth slowly during first six months, and starts commercial production from third year.

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Flowering and fruiting are regular and continuous perhaps between February and December. The stem has a hole in the centre and the size of fruit is 3" – 3-½" × 7" - 7½". Fruits are firm with less shelf life. Trimming, pruning and propping are required for getting proper yield. It is an exhaustive crop and can be grown in different types of soils .

Why Organic? This fruit is a God's gift to mankind towards health and wellness. It is the mandate of the promoter to offer toxin free fruit juice and other products. Therefore it is inevitable to opt for organic farming method, for commercial cultivation, which yields toxin free / chemical traces free output.

Spacing and planting : Rooted cuttings are planted with a spacing of 12' × 3'. In high density planting it can also be planted with 10' × 10' spacing as well.

Challenges: *Morinda citrifolia L.* is a new crop and Organic farming is just re-picking up in India. Govt, Universities, Institutions and departments are yet to endorse organic farming practices; though many success stories are creating ripples in India. Therefore commercial cultivation of Noni through organic farming practices is emerging as an enterprise. Both the crop and the enterprise must succeed.

System: Composting, vermi composting, co-existence of animal husbandry with crop husbandry, bio diversity, botanicals, nutrient management, water management, pest and disease management, weed management, hygiene management, technology management, labour management and documentation are the essential key components perceived in organic farming system. Their inter-play, ultimately manipulate the soil and improves its productivity by improving the humus content in the soil which results in increased and sustainable yield—in terms of quantity, quality and remuneration. Fitting Noni into the systems is easy as is explained below.

Noni cultivation must begin with infrastructures like composting, semi composting, vermi composting, drip, micro-tubes, micro sprinklers and botanicals simultaneously and systematically. Planting Noni in isolations is not organic farming.

Bio Diversity: This must be better visualized and practiced in each and every farm by bringing diverse plants for multipurpose like bio fence, border crop – inter, mixed, companion and antagonistic crop; crops for green leaf manuring and green manuring, pest and disease

management; fodder crops for cattle , mulching and composting. Such a combination is technically possible and financially viable.

Manures / Manuring: Prescription of chemical NPK and FYM must give way for organic sources like compost, vermi compost, oil cakes and slurry. Micro nutrient, deficiencies can also be corrected through botanicals and organic sources. Depending upon the monsoon and wind, manuring schedule has to vary from place to place. However, split and regular applications dose are required to sustain Noni, matching with its ability to continuously flower and fruit as given in the chart – 1 enclosed.

Irrigation: Noni has a tap root system. Irrigation around the ring of root zone through micro-tube is recommended. Growth is less during first six months of planting. Flowering starts from eighth month and they are deflowered – removed till 24th – 36th month. Flowering and fruiting are peak between February and December. Each branch bends down with heavy fruits. Each plant is capable of yielding 130 – 250 fruits. Each fruit weighs around 120 – 170 gms. These facts are taken into consideration while deciding the irrigation system as shown in the chart-2 annexed. In other words, Irrigation must help roots to develop good tap root system. Plants must withstand stress. Mulching and soil cover are to be taken up to minimize water requirement. Excess moisture results in Fusarium Wilt: However, there must be continuous moisture in the root zone, even during severe summer, winter, windy days, that will support continuous, regular flowering and fruiting.

Integrated Pest Management (IPM): Pests like leaf eating caterpillars, grass hoppers, jassids, beetles are commonly seen in Noni. Diseases like Fusarium wilt, root rot, leaf spots as well as nematode problems are also likely to occur. Noni crop is just two years old in the farmers fields in India. Therefore, what is known / seen may not be the end of it.

Use of Botanicals and Organic Inputs: Neem, Vitex, Adatoda, Datura, Calotropis, Andrographis (Kalmegh), Aloe vera, Nuxvomica, *Cissus quadrangularis*, Garlics, Chilly Powder, Asafetida and many others are known Botanicals in use. Fermented extracts are used as foliar spray to control pest and diseases. There are many success stories in India. However optimization, and standardization of these ingredients and their dosage must be scientifically validated for their efficiency. It is for the scientific community to validate these proven on going practices of organic farmers. Till then, such practices will continue and take the lead

like Panchagavya, Cow urine, vermi wash (which are now getting recognition by our Scientific community atleast within 5 - 7 years of wide usage). Use of Beneficial Microbes, traps and pheromones must be encouraged as a package. List of Botanical remedies are enclosed in Annexure – 3. Presentation by Dr. S. Sithanatham; Eminent Entomologist on pest and disease management, may please be read along with this paper.

Weed Management: Weed management in organic farming system must be viewed as under: “There is need for weeds. Weeds are useful biomass as Cattle feed, mulching material and composting inputs. Weeds provide soil cover. Weeds under the canopy are kept away by trenching, mulching and sowing legumes.

Weeds in the inter space are kept under check by cover cropping, inter cropping like, Indigofera, cowpea, horsegram, daincha, senna, *Centella*, Brahmi (Baccoba) Sesbania, *Sesbania grandiflora*, fodder grass etc.

Hygiene: The farm must be always free from glass pieces, bottles, metal pieces, waste cloths (often coming into from farm yard manure or compost purchased); rotten fruits, dry twigs, unwanted undesirable plants (Antagonistic) as shown in the Annexed-4. Such Hygiene will minimize the incidence of insect / pest diseases, to a large extent, as well as avoidable pollution, contamination.

Labour Management: The organic farming system is inter mingled with technology and labour management. Trenching, mulching, use of Botanicals, trimming, pruning, hygiene etc., are much familiar to our agricultural labour force. They are used in conventional farming practices. Even harvesting here means, using secature and not plucking or beating fruits. Use of liquid / bio-fertilizers in small / measured quantity is an art compared to handling of bulk fertilizers, tank silt, farm waste etc.. Change of mindset, orientation, developing faith in the new technology are paramount importance. Otherwise handling of cow urine, rigging earth worms, cowdung and fermented slurry (often with unfamiliar odour) meet with resistance and less involvement.

Documentations: Indian farmers in general are not used to maintain farm records / documents. There may be a few exceptions. They are good in recalling their memories about income/expenses, prices, problems encountered during the course of cultivation etc.. Yet, writing records (in Black and White) of daily activities in the farm like, Block / Field

wise, operations, number of labourers used, Quantity of inputs used, cost / expenses, observations of pest, disease, harvest data, visitors, etc. is useful for costing as well as to create documentary evidence that may support certification process. It should be done by the cultivator himself, or by somebody on his behalf. It is more so a must, as we regard commercial cultivation of Noni as an enterprise.

Viable Models, a few examples: Additional crops (and yet harmless to Noni crop) is easily possible by the following combination. Elevation, soil type, pH, intensity of sunlight and shade, availability of water may decide the combination from this basket. It is possible to fix such combination for each and every farm situations.

- Two in one model of Biogas cum Vermi culture with 2 animals with an investment of Rs.45,000 will generate cooking gas, domestic light plus production of 5 kg. of Vermi Compost per day. This will support two acres of Noni crop.
- An investment of Rs. One lakh in developing Vermi yard will support 5 acres of Noni crop.
- Noni + Silver Oak, Sappan, Bael (Bilva), Amla, Guggal, Kadjuka, Gymnema, Vettiver on the Border will yield continuous and increase income.
- Noni + Border crops + Gliricida, Vitex, Aloe, *Sesbania grandiflora*, Adathoda, Inerva, Calotropis as hedge, avenue plants add income as Botanicals and compost enriching ingredients.
- Noni + Indigo, cowpea, daincha, horsegram, senna, Centella, Stevia, watermelon, pumpkin, ash gourd, fodder grass serve as soil cover, add nutrients, extra seasonal income.

Conclusion

There is urgency for taking up need based research. The ground is now open for many cultivators and research workers to develop techniques for cost effective production of Noni and share their experiences and in the meanwhile comments by onlookers and strangers to this crop need not discourage the entrepreneurs.

Evergreen Revolution in Agriculture through Organic Farming Systems

R.K. Pathak*

Indiscriminate use of agro-chemicals over four decades has adversely affected soil fertility, crop productivity, produce quality and particularly the environment. These generative effects of intensive agriculture have compelled to think for alternative and sustainable system of agriculture. As a result, a number of alternative systems *viz Biodynamic, Rishi Krishi, Panchagavya Krishi, Nateuco organic farming, Homa Organic Farming, Natural Farming and Jaivik Krishi* have emerged in different parts of the country. In these systems, maximum reliance is placed on self-regulatory agro systems and locally available on farm derived renewable resources.

Critical review of different organic systems reveals that cow plays an important role in these organic systems. The cow occupies the highest place of honor in Indian civilization. From ancient times Cow ghee, cow dung, urine and milk were used for seed treatment and for managing the seed health.

The major issues of Organic Farming in present context are :

- Continuous improvement in soil fertility
- Par excellence produce quality
- In put generation at the farm/ village
- Yield equal or better than the conventional systems
- Eco friendly and cost effective technology

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There is number of Organic Farming Systems in which byproducts of cow are used in one or other forms. Brief account of these systems and **Jaivik** package by integrating few of the compatible technologies has been enumerated below

1. Biodynamic Systems

The system appears to be one of the sound alternatives. It is based on systematic and synergistic harnessing energies from **Cosmos; mother Earth, Plants and Cow**. Few of the preparations are used in minute quantities viz; BD-500 to 508, Cow Pat Pit (CPP) and these show remarkable effects on plant growth, metabolism, crop yield and quality. Emphasis is made to adopt an agriculture calendar for cultivation along with special preparations. Emphasis is given to restore soil fertility in form of humus, increase the living system of soil by skillful application of crop rotation. Nutrient requirement is managed by application of Biodynamic compost, duly enriched with Cow pat pit, BD-500; need base use of BD –liquid manures to encourage plant vigor. Pest and diseases are managed by promoting locally adopted varieties, cultural, mechanical measures including use of trap crops, spray of BD-501 and need base spray of BD-liquid pesticides prepared from cow dung, cow urine and locally available herbs along with BD-sets. After 5 years of close observation a BD package was developed at CISH, Lucknow that is self-sustaining to resolve the aforesaid issues.

2. Rishi Krishi

The technology is being promoted by large number of farmers in Maharashtra and Madhya Pradesh. In this technique, rhizosphere soils beneath Banyan tree (*Ficus bengalensis*) are spread over the area and *Amritpani* special bio inoculants prepared from cow dung, cow ghee, honey. It invigorates the living soil and converts a dead soil into living one. It is prepared by thoroughly mixing 250 g ghee into 10 kg of cow dung and 500 g of honey is blended and the mixture is diluted to the tune of 200 liters by stirring. This is utilized for seed treatment (*Bija sanskar*), enrichment of soil (*Bhumi sanskar*) and foliar spray on plants (*padap sanskar*). It is further supplied through irrigation water as fertigation, coupled with mulching with organic waste locally available. The system has been demonstrated successful on a wide range of crops.

3. Panchagavya Krishi

It is a special preparation prepared from five products obtained from cow i.e.; milk, curd, ghee, dung, urine duly fermented along with sugarcane juice, coconut water, mashed banana over a month.

This preparation is rich in nutrients, auxins, gibberellins, and microbial fauna and acts as tonic to enrich the soil, induce plant vigour with quality production. The microbial count of microbes in Panchagavya is given below.

Table 1. Microbial load in Panchagavya

Fungi	38800/ml
Bacteria	1880000/ml
Lactobacillus	2260000/ml
Total anaerobes	10,000/ml
Acid formers	360/ml
Methanogen	250/ml

This solution can be mixed with irrigation water @ 50 liters per hectare either through drip or flow irrigation. This solution is also can be used to treat the seeds; seedlings or other plant parts before sowing/planting. Seed treatment with Panchagavya before storage and its drying in shade is helpful to prolong storage life.

Periodicity

1. Pre flowering phase Two sprays @ 15 days, depending upon crop duration
2. Flowering and pod setting Two sprays @ 10 days intervals
3. Fruit/ pod maturation Once during pod maturation

Its remarkable effects have been demonstrated in fruits like mango, guava, acid lime, banana, spice turmeric, flower-jasmine and vegetables such as cucumber, spinach etc

4. Natural Farming

It consists of use of *Bizamrit* (cow dung, urine, lime, virgin soil) for seed/set/seedling treatment, followed by regular use of *Jiwamrit* (cow dung, urine, jaggery, pulse flour, virgin soil). It is prepared by mixing 10 kg of cow dung + 5-10 liters of cow urine + 2 kg each of jaggery, pulse flour and one kg of virgin soil by thorough mixing with water. It is diluted to the tune of 200 liters, which is sufficient to irrigate one-hectare area. *Jiwamrita* is a rich bio-formulation and contains consortia of microbes as evident from table 2.

Table 2. Showing microbial analysis of Jiwamrita

Organism tested	Viable cells
Azospirillum	2×10^6
Phosphorus solubilizing microorganism	2×10^6
Pseudomonas	2×10^2
Trichoderma	2×10^6
Yeast & moulds	2×10^7

Source- Biocentre- Bangalore

This formulation should be used within 3-7 days of preparation. It can be used through irrigation water either by flow drip, or sprinkler system at 15 to 30 days interval as per convenience. This can also be used by thoroughly by drenching the mulches in between the vacant space available.

5. Natueco farming

It follows the principles of eco-system networking in farming system approach. Knowing nature more closely, through critical scientific inquiries. It is an ever growing, novel, unique, participatory trust between man and nature. It has a new vision of infinite resource potentials in Nature and sunlight promises ***plenty for all*** through harvesting all these resources. This depends on critical understanding of greening and recycling of biomass within the neighbour hood to enrich the structure and fertility of soil in a calculated way. The three relevant aspects of Natueco farming are-

Soil: Enrichment of soil by recycling the biomass and establishing a proper energy chain. The basic component of this technology is “*Amrit Mati*” a special bio-formulation rich in microbial consortia prepared from “Amrit Pani” fermented solution of cow dung, urine duly enriched with locally available organic waste, upper crust of soil, and decomposition of foliage from different crops at various stages of its maturity for ensuring availability of macro and micro-nutrients. It takes almost 90-100 days in preparation of *Amrit mati*.

Roots: Development and maintenance of white root zones for efficient absorption of nutrients

Canopy: Harnessing solar energy through proper canopy management. The main aim of this is to capture maximum solar radiation in efficient way by promoting multistoried cropping for maximizing production per unit area

6. Homa Organic Farming

It is totally a revealed science. It comes from Vedas, the most ancient body of knowledge known to mankind. It is a **Super technology**, which simultaneously negates the effects of polluting factors while increasing per unit area of quality production. The knowledge can be used beneficially to grow crops without chemicals and pesticides. It is known as **Homa Organic farming**. The process of “Agnihotra Pyramid Fire” is the basic Homa Agnihotra is a must to sustain life now on this planet. In fact, it is a gift to humanity from ancient most **Vedic** sciences of bio energy, medicine, agriculture and climate engineering.

Agnihotra is the basic fire in Homa Therapy. It is a process of purification of the atmosphere through the agency of fire, prepared in a copper pyramid tuned to the biorhythm of sunrise/sunset. As an impact of Agnihotra, tremendous amount of energy is gathered which creates a magnetic field? This neutralizes the negative energies and reinforces positive energies. Pyramid is generator, and the fire is turbine. Cow dung, ghee and rice then interact to form a composition, which thrusts and provides nutrients for survival, yield and quality production.

It injects nutrients into the atmosphere to prevent diseases and bring natural predators. As a result, healthy micro-flora and fauna is created. This gives rise to a microenvironment or micro-system, which is comparatively less toxic to the growth of plants. After creation of a microenvironment, creatures like earthworms thrive better. They eat the soil, digest it again and replenish the soil.

It has been observed that when “Agnihotra Ash” is added to the normal soil, it increases water soluble phosphate content of the soil and nutrients are absorbed readily by the root hairs of the plants. Absorption of macronutrients like nitrogen, phosphorus, Potash because of small cells and active transport is helped in Homa atmosphere.

A special bio-formulation developed by Gloria and named as “Gloria biosol” from Peru is prepared after a series of operations and processes that lead to the biodegradation of organic matter, worm humus, fresh cattle manure and water, until reaching mineral grade. It is powerful bio-food and bio-fertilizer for the plants with high macro and micronutrients.

In different countries on several continents agricultural projects have been carried out using Homa Therapy. Following are some documented results:-

Rejuvenation of soils- The soil improves through Homa therapy even in difficult climatic conditions such as acid rain

Prevention, control and eradication of plagues and diseases in all crops with short and long vegetative cycles

Weed control- Homa therapy controls and eradicates weeds

Reports are available for various crops with Homa Organic Farming such as:

- Cereals-Rice, corn, wheat, sesame
- Vegetables-tomato, onion, cabbage, cucumber, beans, potato
- Fruits- Banana, plantain, papaya, cocoa, mango, coconut, orange, lemon
- Nut-Walnut, pea nut
- Commercial crops-Cotton, coffee
- Crops become superior in quality, taste, texture, colour and disease resistance.
- Improvement in self life of produce
- Homa technology is cheap and there is no need of any agro-chemicals
- Homa therapy improves quality and quantity of milk
- Homa improves the health of cattle and no vaccinations are required

- Homa beneficially affects earthworms and honey bees and they produce more
- Now it is necessary to establish Homa seed banks and Homa tree farms to survive

Package of Practices JAVIK Production of Horticulture Crops

The six systems i.e., *Biodynamic*, *Panchagavya*, *Rishi Krishi*, *Natueco*, *Natural farming* and *Homa Organic Farming* are capable of independently meeting challenges of organic production. Looking at the strength of these systems and experience gained at CISH, Lucknow, efforts have been made to integrate few of these techniques to develop a *Jaivik* package which can be easily adopted by a common Indian farmer with few days training and some appropriate literature.

Proposed package of *Jaivik Krishi* for horticultural commodities in general has been summarized below :

Seed & Planting Materials

- In Jaivik krishi, locally adopted varieties are preferred over the hybrids
- Efforts need to be initiated to produce seeds and planting materials by Jaivik techniques
- In case, such seeds are not available efforts during storage agro-chemicals should not be used
- Seeds/seedling and plant parts such as cuttings, tubers, corms, rhizomes, etc should be treated with any of cow by products such as cow urine, bijamrita, Cow Pat Pit etc.

Nutrient Management

- Growing of legumes for green manuring or as inter/cover crops as per requirement and as per calendar.
- Application of organic manures (10-20kg/tree) or 4-5 t / per hectare for field crops through NADEP/ Vermi/ Biodynamic Compost (BD) or Microbe Mediated Compost (MM Compost) in descending moon period

- Mulching after application of 100g CPP, spraying of cow horn manure (BD-500) / *Panchgavya* / *Amritpani* / *Jeevamrita* or vermiwash
- Need based foliar spraying of biodynamic liquid manures/vermi wash/cow pat pit (CPP) in ascending Moon phase.

Pest Management

- Spraying of Biodynamic/ Organic pesticides/ prepared from cow urine, neem, karanj (*Pongamia pinnata*), Lantana, *Caliotropis procera*, castor, *Thevetia nerifolia*, *Vitex* sp. leaves as per experience.
- Regular performance of *Agnibotra* at sun set and sun rise in the farm if possible
- Nettle leaf/ kalmegh leaf extract sprays to control hard pests like mango hopper, mites etc.

Disease Management

- Biodynamic tree paste/cow dung paste for the control of gummosis and dieback.
- Two sprays of cow horn silica (BD-501) at flowering and fruit development stage, particularly on Moon opposite to Saturn phase
- Spraying of horsetail (*Equisetum arvensis*)/casuarina leaf extract for the control of fungal diseases in ascending Moon period.

Effect of Growth regulators on rooting of hollow and non hollow cuttings of *Morinda citrifolia* L.

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Abstract

The investigation on rooting behaviour of cuttings of Morinda citrifolia treated with growth regulators showed that the growth regulator IBA at three different concentrations viz., 2000, 4000 and 6000 ppm significantly increased rooting of cuttings and number of primary roots over control. Among different concentrations IBA at 4000 ppm exhibited the best performance (50 % of rooting success, 4.0 no. of primary roots) while at 2000 ppm it had a declining effect on the different rooting parameters.

Key Words: Morinda citrifolia, Growth regulators, IBA, rooting behaviour

Introduction

Noni, *Morinda citrifolia* L. also known as Indian Mulberry, is one of the important fruit plant of Rubiaceae family. Noni is propagated either from seed or stem cuttings. But the prime disadvantage behind seed propagation is that without seed treatment, germination takes 6-12 months or more, whereas stem cuttings can be rooted in approximately 1-2 months. Cultivation of noni plants from stem cuttings reduces the time required to obtain plants that are ready for transplanting. The goal of vegetative propagation is to get the best planting stock with highest genetic quality material (Hartman and Kester, 1983; Nanda, 1970; Wright, 1975). For propagating plants through cuttings, it is essential to know the proper techniques for vegetative propagation of this crop. As it is having wide adaptability

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under adverse agro climatic conditions such as salinity, infertile and in Tsunami affected lands etc., deserve very rapid extension of its cultivation in the Islands as a whole. To make it successful in Andaman and Nicobar Islands there is immediate need for large-scale production of planting material by vegetative means preferably through cuttings, which is considered to be the easiest and the cheapest method. Since, auxins like naphthalene acetic acid and indole butyric acid have been reported to show quick and better rooting in vegetative propagation of many fruit crops viz. guava, grapes, ber, custard apple, (Shanmugavelu, 1987; Singh and Singh, 1973; Banker, 1989 ; Dhua et al., 1982).

With the above facts in view, the present investigation was conducted to find out the effect of growth regulator on rooting of cuttings of *Morinda citrifolia* grown under A & N Island condition.

Materials and Methods

The present experiment was conducted during March-June, 2005 at Central Agricultural Research Institute, Port Blair. The cuttings taken for the experiment were 20cm long and 2.0 to 3.0 cm in diameter from two year old shoots of approximately 20 years old trees located near the Institute. The cuttings were dipped for 15 seconds in 2000, 4000 and 6000 ppm solutions of IBA separately while cuttings without chemical treatment were treated as control. Twenty cuttings were taken as a unit of treatment and each treatment was replicated quadruplicate. Then treated cuttings were planted in poly bags (6x8cm) filled with soil + compost. Monthly observations on various parameters were recorded. The rooted cuttings were transplanted on the same day after the root studies and further observations in respect of percentage of survival were recorded. These data were then statistically analysed following the RBD.

Results and Discussions

The results revealed that the cuttings treated with 2000, 4000 and 6000 ppm of IBA respectively promoted root and shoot growth and establishment. This observation supports the findings of Dettweiler who opined that the application of growth regulators caused greater metabolic

activity and mobilization of sugars and nitrogenous substances from stems and leaves, which helped in the initiation of root. Percentage of rooting, number of primary roots and length of longest primary root were significantly high over control when the cuttings were dipped in 4000ppm IBA. Auxin plays an important role in the metabolic activities and cell division process, which results in an increased root growth (Edmond et al., 1997). Cuttings treated with 6000ppm IBA produced maximum roots (91.0) and length (22.7cm) per cutting, significantly higher than 2000 ppm IBA (44.7), while control recorded only 20.8. number. of leaves were highest in IBA 6000ppm (24.7) followed by IBA 4000ppm (19.0) respectively. In both the cases, IBA 6000ppm showed significantly higher values than IBA 2000ppm. In case of average length of longest branch, IBA 4000ppm gave highest length (12.8cm) followed by IBA 6000ppm (10.8cm) and IBA 2000ppm (9.90cm). Initiation and percentage of sprouting was maximum in non-hollow cuttings compared to hollow cuttings. The better effect of IBA may be due to its translocation property or it is destroyed slowly by auxin destroying enzyme system (Singh and Singh., 1973). However, high level of auxins associated with comparatively reduced root growth would have retarded the carbohydrate metabolism and caused nutritional imbalance as suggested by Spiegel (1954) and Nanda et al., (1974).

Conclusion

Among the different concentrations of IBA tried for rooting of cuttings in noni, 4000 ppm showed enhanced results in terms of rooting percentage, number of primary roots, length and diameter of roots and cutting establishment. Better root initiation and establishment were observed in non-hollow cuttings compared to hollow cuttings.

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Table 1. Effect of different levels of growth regulators on root formation in the cuttings of *Morinda citrifolia*

Treatments	Rootings (%)	No. of Primary roots,cm	Length of Primary roots,cm	Dia. of thickest root,cm	Secondary rooting (%)			Cutting establishments(%)
					Profuse	Countable	Nil	
IBA – Non Hollow cuttings								
2000 ppm	30.00	4.8	17.0	0.33	29.68	47.54	22.56	47.79
4000 ppm	50.00	5.2	24.8	0.67	30.78	49.29	19.92	72.35
6000 ppm	40.00	4.8	22.0	0.49	26.07	42.96	22.63	58.34
IBA -Hollow cuttings								
2000 ppm	30.00	3.3	12.8	0.25	25.32	38.25	19.52	42.25
4000 ppm	40.00	4.8	20.9	0.61	28.27	45.75	15.75	68.72
6000 ppm	40.00	4.3	18.5	0.50	24.23	38.28	13.25	50.28
Control	33.12	4.2	17.2	0.29	21.88	36.40	41.72	37.1
CD(0.05)	2.85	0.95	1.28	0.92	NS	13.89	0.85	0.78

Effect of Pre-sowing treatment on seed germination and seedling vigour in *Morinda citrifolia* var. *citrifolia*, an indigenous medicinal fruit suitable for Tsunami affected land

D.R.Singh¹, R.C.Srivastava*, R.Sudha¹ and T.Damodaran¹

Abstract

Morinda citrifolia L. (Rubiaceae), indigenous to Andaman and Nicobar Islands, is an endangered medicinal fruit plant for which ex situ cultivation has been recommended as a conservation strategy. However seeds of this species show poor germination. Pre sowing treatments in noni with different chemicals and growth regulators were carried out under protected house condition. The treatments included were GA₃ (20ppm), KNO₃ (150 ppm), NaHClO₃ (5% available chlorine for 30 minutes) and control. Results revealed that, highest mean germination percentage (MGP) was recorded in NaHClO₃ treatment, number of days taken for first seed germination was low in GA₃ treatment and lowest mean germination time (MGT), highest plant height, root diameter, root length, fresh weight of shoot and root, dry weight of shoot and root and seedling vigour index (SVI) were observed in KNO₃ treatment followed by NaHClO₃ treatment. The study indicates that KNO₃ and NaHClO₃ treatments can effectively improve the germination and increase the seedling vigour of noni.

Key words : *Morinda citrifolia* L. Pre sowing treatments, seed germination, seedling vigour.

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Introduction

Morinda citrifolia L., known commercially as noni which is also called as burmaphal, pongi and suraogi by the Burmese, Nicobarese and Andamanese tribals respectively (Shant and Rao, 1973). Noni is native to maritime forests of Northern Australia, the western Pacific, and Indian Oceans (Stevens *et al.*, 2001) and now found throughout the tropics. It also grew as wild in Andaman and Nicobar Islands. It is one of the most important botanical remedies and food supplements traded on the international market. Juice from ripe or immature fruits can increase mental clarity and attention span, as well as allow greater physical performance levels. Leaves, bark and roots are used for a great many maladies, pain, arthritis, diabetes, high blood pressure, skin and stomach ulcers, depressions, senility, diarrhoea, arteriosclerosis, cancer, AIDS and skin parasites (Tan, 2001).

For unique medicinal value and other properties, the tribals of Andaman and Nicobar Islands used to eat this fruit with salt. The amazing gift of health and well being that nature had endowed it in the form of Noni, which is one of the most important food supplements traded on the international market. It is usually sold as fruit juice in India by Indian Noni Research Foundation (INRF), Chennai, India. Recently its importance was made known to local people by the Founder of INRF, Chennai, hence the local farming community is interested to take up its cultivation in large scale, for which they need planting materials. More recently, high trade has threatened its natural populations and many become endangered and become further extinct due to poor seed germination. Using seeds of Hawaii population of Noni, "Francis and Rodriguez" reported only 24% maximum germination.

An expert group prioritized noni for conservation through exsitu cultivation for Andaman and Nicobar Islands. Enhancing seed germination and developing vigorous seedlings are crucial for this purpose. Pre-sowing chemical treatments have generally been used to enhance seed germination (Kattimani *et al.*, 1999) and to increase seedling vigour (Pandey *et al.*, 2000). Hence the study was taken up to develop effective pre-sowing treatments to stimulate seed germination and seedling vigour and identify morphological traits for the assessment of healthy seedlings of *Morinda citrifolia*.

Materials and Methods

The experiment was carried out at Central Agricultural Research Institute, Port Blair. Fruits of *Morinda citrifolia L.* were collected from moist, humus-rich seashore forests of Wandoor, South Andaman (altitude 2.0-3.0m), dried the extracted seeds for four days at room temperature ($30 \pm 2^\circ\text{C}$) and stored in an air tight box before experimentation. Seeds were screened for their viability. Seed viability was observed at immediately after collection (95%) and at the time of germination tests (98%) using the tetrazolium test (Agarwal *et al.*, 1973). Healthy seeds were selected and used for all the treatments. The treatments included GA_3 (20 ppm), KNO_3 (150 ppm) and NaHClO_3 (5% available chlorine for 30 seconds) and control was maintained using distilled water. Treated seeds were sown (0.5 cm depth) in polythene bags (6''x8'') in a mixture of Farm Yard Manure and sandy loam soil in equal volume. The experiment was laid out in a completely randomized block design with three replications (50 seeds/replicate) under a protected house (top covered with PVC sheet) (temperature $31.5 \pm 2.5^\circ\text{C}$ max. $26.5 \pm 2.5^\circ\text{C}$ min.; RH 85.5 ± 2.5 max., 75.5 ± 2.5 min.). Observations were recorded on seed germination, plant height, root length, root diameter, fresh weight of the shoot and root, dry weight of the shoot and root and seedling vigour index. The mean germination time was calculated by using the relation, $\text{MGT} = \frac{\sum (fx)}{\sum x}$, where x is the number of newly germinated seeds on each day, and f is the number of days after seeds were set to germinate (Nicholas and Heydecker, 1968).

These parameters were recorded in the five randomly selected seedlings from each replication. The oven-dry weight was obtained by drying the seedlings at 70°C to constant weight. Realizing the importance of dry matter accumulation in healthy seedling and low mean germination time (MGT) as indication of seed vigour and uniform seedling, a method was developed to determine the seedling vigour index as, $\text{SVI} = \frac{\text{dry weight per seedling}}{\text{MGT}} \times 100$.

Results and Discussion

All the treatments except control improved the seed germination and reduced the MGT. Among the treatments, seeds treated with GA 20 ppm recorded the lowest MGT. This may be due to the combination of endogenous GA and applied GA which might have induced early germination by increased hydrolysis of starch and their translocation to the growing seedling

(Das and Patnaik, 1971). Early seed germination was recorded in KNO₃ treatment whereas NaHClO₃ treatment significantly increased the percentage of germination, thus confirming the role as a stimulating agent (Joshi and Dhar, 2003). These treatments may help early germination of seeds, providing them competitive ability (Nelson, 2005) and hence reducing chances of their mortality.

Plant height appeared to be the strongest morphological trait and it was convenient to identify vigorous seedlings of *Morinda citrifolia L.* Highest plant height, root length, root diameter, fresh weight of the root and shoot and dry weight of the shoot and root were recorded in KNO₃ treatment. This phenomenon may be due to the increased activity of nicotiamide adenine dinucleotide phosphate reduced (NADPH₂) by K positive ions (Hendricks and Taylorson, 1975). KNO₃ and NaHClO₃ significantly enhanced plant height, whereas root length was significantly greater values for KNO₃ and GA₃. However, root elongation in some medicinal plants was positively influenced by KNO₃ and negatively by GA₃ (Joshi and Dhar, 2003). The increased fresh and dry weight of seedlings may be due to the enhanced root and shoot length and number of leaves have lead to the overall assimilation and redistribution of photosynthates within the plant and resulted in higher fresh and dry weight of seedling and increased dry matter assimilation (Choudhary and Chakrawar, 1982). In general, negative correlation was obtained for seedling dry weight with days taken for first germination and MGT.

Among the treatments highest SVI was observed in KNO₃ treatment, which is followed by NaHClO₃ treatment. Root diameter, fresh weight of the shoot and dry weight of the root were significantly correlated with SVI. The reason for highest SVI might be due to the increased dry matter production in the concerned treatment. Similar result was observed in seedling dry weight in *Withania somnifera* (Joshi and Dhar, 2003).

Control seeds started to germinate only when other treatments already reached 90% of their germination. This difference in treated seeds might be due to altered physiology of embryos and liberating enzymes, so that developmental processes occur more rapidly after sowing in the treated seeds (Leite et al., 2003) and the treatments were stimulatory to overall seedling growth.

Conclusion

Among the different chemicals and growth regulators attempted to increase the germination efficiency of noni seeds, NaHClO₃ treatment exhibited higher seed germination and KNO₃ treatment exhibited highest plant height, fresh and dry weight of root and shoot and seedling vigour index. The study suggests KNO₃ and NaHClO₃ treatments are economic and easily applicable by nursery workers and poor farmers in developing mass planting stock, compared to the costly plant growth regulators and associated technicalities.

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Table 1 : Effect of pre-sowing treatments on germination and seedling growth of *Morinda citrifolia* under protected house conditions

Treatment	Time taken for seed germination (days)	Plant height (cm)	Root length (cm)	Root diameter (mm)	Fresh weight of the shoot (g)	Fresh weight of the root (g)	Dry weight of the shoot (g)	Dry weight of the root (g)	Seedling vigor index
Control	70.7	26.2	12.0	5.59	1.822	1.016	0.367	0.325	0.733
GA ₃ (20 ppm)	41.0	28.9	16.0	6.06	2.082	1.986	0.408	0.422	1.408
KNO ₃ (150 ppm)	38.7	44.8	16.4	8.79	5.463	3.444	1.102	1.124	3.661
NaHClO ₃ (30 min.)	44.0	39.8	12.7	7.93	3.093	2.571	0.769	0.923	2.282
CD (0.05%)	19.75	NS	NS	NS	NS	NS	NS	NS	NS

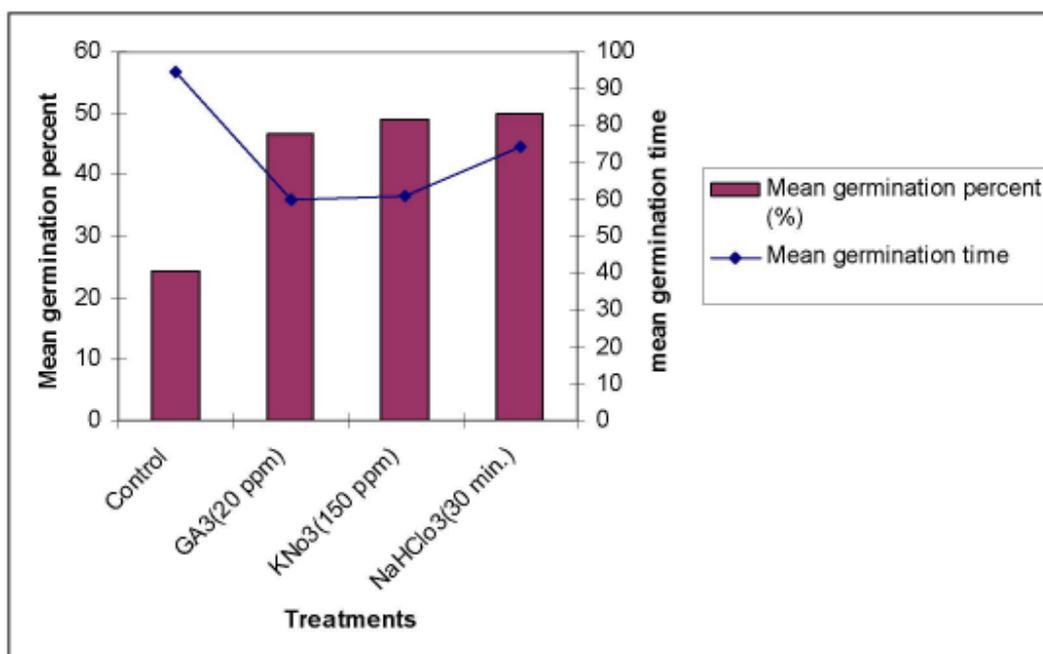


Fig. 1. Effect of pre-sowing treatments on Mean germination percent and Mean germination time of *Morinda citrifolia* under protected house conditions

Studies on growth and development stages of *Morinda citrifolia* L. (Noni) fruits

D.R.Singh¹, R.C. Srivastava*, and R. Sudha¹

Abstract

An experiment was conducted to study the physiology of fruit growth and development of the Morinda citrifolia L.. fifty flowers from 10 trees of two-three years old were selected and tagged. Fruits were collected from the tagged trees at 10 days interval and analyzed. The results indicated that the length, diameter, weight and moisture content of the fruits were increased slowly during the first phase, rapidly increased second phase and again gradually increased during maturity. The TSS, Sugar-acid ratio and ascorbic acid content of the fruit increased towards maturity whereas the acidity content declined towards maturity.

Introduction

Noni is a tropical wandering plant indigenous to areas of Australia, Malaysia and Polynesia. It is considered native to Southeast Asia although it grows from India to the eastern region of Polynesia. *Morinda citrifolia* L., has a long history of medicinal use in these areas. The plant is found growing in open coastal regions around lava flows at sea level and in forest areas up to about 1300 feet above sea level. Research shows that all parts of the *Morinda citrifolia* L. plant, roots, seeds, flowers, leaves, and fruit may have a variety of positive health implications. *M. citrifolia* is a large shrub to medium tree varying between 3 metres and 12 metres high. It has oval shaped leaves to about 300 mm long by 150 mm wide. The white flowers occur in the leaf axils in clusters. They are followed by succulent fruits which fuse into a large compound structure as they ripen. The mature noni fruit is about the size of a potato, green or yellow in colour. When ripe the fruit turns yellow and white. Every time, cracking and bruising at harvest time render low market value of fruits. Therefore, some growers prefer to

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harvest large fruits sooner and allow other fruit to grow more to obtain a bigger size. In order to maximize yield and quality fruits, it is necessary to know the phases of growth that are susceptible to environmental manipulation. There is little information available on the physiology of fruit growth and development of noni fruit. Considering the potential importance of this fruit, present study was conducted to study in detail its growth and development.

Materials and Methods

The experiment was conducted using 2-3 years old *Morinda citrifolia L.*, trees at Central Agricultural Research Institute, Port Blair. The trees received routine cultural care suitable for commercial fruit production. About 50 flowers were tagged at full bloom stage to provide fruit samples and their growth and development were observed by sampling 10 fruits every 10 days. The fruits were transferred to the laboratory immediately after harvest. Fruit length and diameter were measured. Fruit samples were picked for chemical analysis 70 days after full bloom every 10 days till harvest. Hand refractometer was used to determine the TSS content. Total acidity was measured by titration with 0.1N NaOH. Ascorbic acid content were determined by titration against 2,6-dichlorophenol indophenol dye solution (AOAC, 1984).

Results and Discussion

Measurement of fruit length and diameter indicates three phases of growth. First phase starts from 10 days after full bloom to 20 days after full bloom. During the first phase the overall growth of the fruit was slow. All the physical parameters of the fruit increased gradually. The overall slow growth during this phase might be associated with cell division.

A rapid second phase was from 20 days after full bloom to 40 days after full bloom. This is the period of seed formation and development along with pulp formation. In this phase growth of the fruit was rapid. This rapid increase in fruit growth might be due to cell enlargement and also due to the development of seed in the fruit as the seeds are regulatory substances in fruit growth. Third phase may be called as the stage of maturation which started from 40 days after full bloom to maturity of the fruit. During this phase, the rate of increase in fruit growth dropped down. The slow growth during the period might be attributed to the retardation of pericarp growth which might be due to rapid hardening of endocarp.

Length and diameter of the fruit increased slowly during the first phase (2.10cm to 2.20 cm of fruit length and 1.30 cm to 1.90 of fruit diameter). Weight and moisture content of the fruit also increased from 1.92 to 5.75 gm and 84.00% to 85.00% respectively during first phase. During the second phase, there is rapid increase in fruit weight, diameter, length and water content of the fruit was observed. Fruit weight increased from 5.75 to 15.25 gm, fruit diameter raised from 1.90 to 2.70 cm, fruit length from 2.10 to 2.80 cm and moisture content increased from 85.0% to 88.4%. The rapid growth of the fruit corresponds to the phase of cell division in the fruits (Nitsch, 1953). During the second phase, seed formation and development are taking place. Blumenfeld (1980) reported a positive correlation between seed and fruit weight in loquat. This is followed by a transitory period after which there is a decline in growth rate which occurs over the phase during which cell expansion takes place in response to the accumulation of carbohydrate and water (Schechter et al., 1993).

Fruit weight, diameter, length and moisture content continuously increased till maturity but in the third phase the rate of increase was slow. These parameters grew continuously throughout the growing season during the fruit development (Table 1). Noni fruit length increased faster than diameter during the growing period.

Variation in biochemical components during fruit development was shown in Table 2. Only 70 days after full bloom, it was possible to squeeze juice from the fruits. The sugar content of the juice measured as TSS increased gradually during fruit growth and development. TSS increased from 7.09 to 8.11°Brix during maturity. The increased TSS of noni fruit with fruit maturity is probably a result of increased hexose sugar accumulation during fruit ripening (Al-Maiman and Ahmad, 2002). The titrable acidity of the juice decreased with advance in maturity reached 0.56 % at harvest time (Table 2). The ascorbic content and sugar-acid ratio increased towards maturity and reaches 125 mg/100gm and 14.48 respectively. The sequence of changes in fruit colour was in the order of green, light green, light yellow and finally yellowish during the final stage of fruit development/the gradual change in colour with the advance of maturity may be due to the degradation of chlorophyll content.

Conclusion

Changes occurring during fruit growth and development of *Morinda citrifolia L.*, were studied. Fruit growth patterns were determined at 10 days interval by measurement of diameter, length, fruit weight. Noni fruit shows a sigmoid pattern of growth both on diameter and length basis. TSS of the fruit increased while total acidity decreased throughout the growing season.

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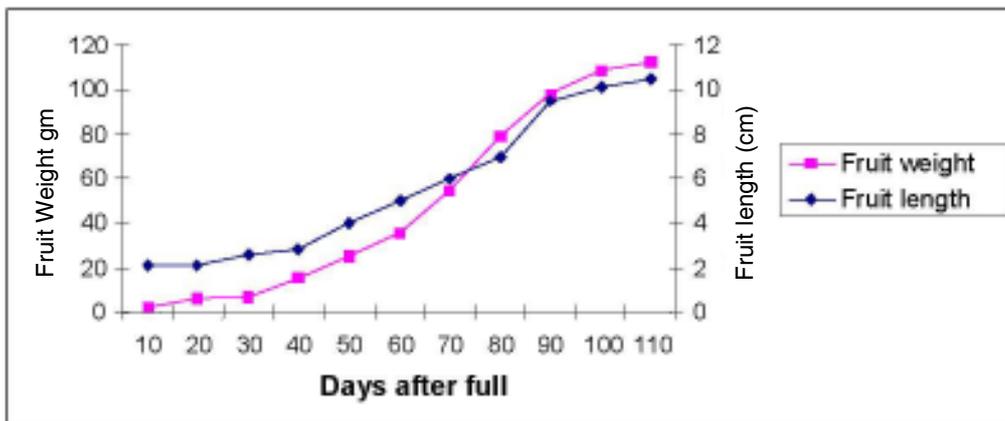
Table 1: Changes in length, diameter, weight and moisture content of *Morinda citrifolia* L. fruit during different fruit development stages

Days after full bloom	Fruit weight (g)	Fruit length (cm)	Diameter of the fruit (cm)	Moisture content (%)
10	1.92	2.10	1.30	84.0
20	5.75	2.10	1.90	85.0
30	7.15	2.60	2.20	88.0
40	15.25	2.80	2.70	88.40
50	24.80	4.0	3.70	90.30
60	35.50	5.00	4.20	92.14
70	54.75	6.00	4.70	91.25
80	78.90	7.00	4.90	90.18
90	98.15	9.50	5.25	92.50
100	108.25	10.10	5.80	95.50
110	112.50	10.50	6.20	96.50
SEd	0.84	0.24	0.17	1.52
CD (0.05%)	1.74	0.50	0.35	3.18

Table2: Changes in chemical constituents of *Morinda citrifolia L.* fruits at different stages of fruit development

Days after full bloom	TSS (° Brix)	Acidity (%)	TSS – Acidity ratio	Ascorbic acid (mg/100g)
70	7.08	0.59	12	89.13
80	8.08	0.57	14.17	95.40
90	8.09	0.57	14.19	95.70
100	8.11	0.54	15.02	110.50
110	8.11	0.56	14.48	125.00
SEd	0.20	0.04	0.23	0.57
CD(0.05%)	0.47	0.10	0.52	1.32

Fig. 1: Changes in weight and length of *Morinda citrifolia* fruit during different fruit development stages



Influence of Noni (*Morinda citrifolia* L.) herbal extracts on growth and production of chillies var. Arka Lohit

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Abstract

*Chilli, *Capsicum annum*, both green and dry is a remunerative crop in Andaman & Nicobar Islands. However, especially during the rainy season (June-September) the crop is more prone to mosaic diseases. Management of plant viral disease is difficult as it involves vector control. The indiscriminate use of pesticides is very common to mitigate pest problems. Of late, much emphasis is being paid globally on organic farming with large-scale use of organic manures, biofertilizers, biopesticides and plant extracts for growth promotion and quality of the products without residues of pesticides. The present investigation was carried out in Central Agricultural Research Institute, Port Blair to find out the influence of noni herbal extracts on mosaic incidence and related growth and productivity of chillies. Seeds of chillies variety Arka Lohit were sown on nursery beds and the seedlings were transplanted to the mainfield at 45x45 cm spacing. Plant population was maintained at 36 plants / plot. Nearly 25% of the population was already affected by mosaic diseases before the treatments started to impose. Different herbal extracts tested are NONI Ayur, NONI Vardhini and NONI Rakshak at the concentration of 2 ml/lit. Treatment include spraying of different natural extracts of noni at 30 days interval from the date of transplanting till the flowering. Results revealed that the vegetative and reproductive parameters are significantly influenced by the spraying of noni extracts compared to control. The mosaic disease incidence in the NONI herbal sprayed plots did not increase from its earlier level due to complete reduction in vector population. It was also noticed that earlier infected plants also recovered*

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well, when compared to 100% incidence of mosaic in control plot. Highest plant height (117.89 cm), plant spread (81.06 cm), number of branches (6.33), was recorded in plants sprayed with NONI Ayur herbal extract followed by NONI Vardhini. Minimum days taken for flower setting (38.56 days), fruit setting (43.50 days), fruit maturity (58.22 days) was observed in NONI Vardhini sprayed plants followed by NONI Ayur whereas in control it was registered 40.67 days for flower setting, 45.67 days for fruit setting, 59.78 days for fruit maturity. Yield parameters like highest number of fruits per plant (144), yield per plant (314 gm), yield per hectare (135.4 quintals) was registered in NONI Vardhini herbal extract sprayed plants whereas in control it was observed as 110.3 fruits per plant, 190 gm yield per plant and 87.44 quintals yield per hectare. NONI Vardhini herbal extract sprayed plants also exhibited maximum fruit quality parameters viz., fruit length (5.32 cm), fruit diameter (0.64 cm), individual fruit weight (Green) (3.32 gm), number of seeds per fruit (58.60) and seed weight per fruit (1.06 gm) whereas in control which was recorded as fruit length of 4.67 cm, fruit diameter of 0.47 cm, individual fruit weight of 1.99 gm, number of seeds per fruit of 32.1 and seed weight per fruit of 0.85 gm.

Introduction

Chilli is considered as one of the most important remunerative crop in Andaman & Nicobar Islands. Chilli is a rich source of vitamin C and provitamin A (β -carotene) (Lee et al, 1995). Both green chillies and dried pods fetching a good return to the farmers. In chillies crop losses inflicted by diseases are becoming one of the major limiting factors affecting plant growth and yield. In Andaman & Nicobar Islands, major problem for growing chillies is the devastating viral diseases, especially during the rainy season (June-September) the crop is more prone to mosaic diseases. Among the viral diseases affecting chilli, chilli mosaic virus is the most prevalent and causes an yield loss of 20-75% (Hedge and Kulkarni, 2001). Management of plant viral disease is difficult as it involves vector control. Aphids are key vectors in the transmission of chilli viruses caused by CMV (75%), TMV (54.2%), TSWV etc (Qing et al, 2001). The indiscriminate use of pesticides is very common to mitigate pest problems. The prolonged and overuse of chemical pesticides has resulted in several ill effects such as health hazards, ecological imbalances, development of resistance to pests, resurgence of pests, emergence of newer pests and environmental pollution. All these factors led to a

search for safer and more compatible alternatives among which natural products are of first importance. Therefore, a study was conducted to evaluate the potential of *Morinda citrifolia* herbal extracts on mosaic incidence and related growth and productivity of chillies

Materials and Methods

The field experiment was conducted at Central Agricultural Research Institute, Port Blair on chilli variety Arka Lohit. There were three noni products (herbal extracts) treatments comprising: 1. Noni Vardhini 2. Noni Ayur 3. Noni Rakshak which were tested against a control in a randomized block design with five replications. The recommended cultural practices were followed uniformly in all the plots. Different products of noni herbal extracts were applied @ 2 ml/lit each at 30 days interval from the date of transplanting to flowering. Observations on randomly selected plants were recorded for quantification traits viz., plant height (cm), plant spread (cm), Number of branches, number of days taken for flowering, number of days taken for fruit setting, number of days taken for maturity, number of fruits per plant, fruit length and diameter (cm), individual fruit weight, number of seeds per fruit, seed weight, yield per plant and yield per hectare (quintals). The collected data were subjected to statistical analysis as per the method recommended by Panse and Sukhatme (1970).

Result and Discussion

The noni herbal extract treatments significantly influenced the growth and yield parameters in chillies. Higher plant height of 117.89 cm was recorded in Noni Ayur herbal extract treatment. However, all the herbal extract treatments exhibited higher plant height compared to control.

The foliar application of Noni Ayur also resulted in maximum plant spread (81.06 cm) and number of branches (6.33).

Table 2 clearly shows that application of Noni Vardhini herbal extract had a significant effect on days taken for flowering, fruit setting, days taken for fruit maturity. Noni Vardhini herbal extract treatment taken minimum days for flowering (38.56 days), minimum days for fruit setting (43.50 days) and minimum days taken for fruit maturity (58.22 days) compared to other treatments.

Similar effects were observed in various yield and yield attributes. Spray of Noni Vardhini herbal extract resulted in significantly higher number of fruits per plant (144), yield per plant (314 gm) and finally yield per hectare (135.4 quintals) and proved significantly superior than control.

Among the products Noni Ayur acts at cellular level and develops the plants resistance to pest and disease attack. It also has strong repellent properties and ovicidal effect on insect eggs whereas Noni Vardhini increases the resistance mechanism of the plant and also supplies major plant nutrients in organic form which ensures quick growth and strengthen the plant root growth. Noni Rakshak is exclusively used against viral diseases and soil borne diseases. It checks the spread of diseases by suppressing the pathogen.

The improvement in yield per plant and per hectare because of Noni vardhini herbal extract application might be correlated to their effect on vegetative growth characters like plant height, number of branches and plant spread. These might be have built up adequate food stock for developing more number of large sized fruits and that might have led to higher yields.

Noni Vardhini treatment also registered maximum fruit length (5.32 cm), fruit diameter (0.64 cm), individual fruit weight (3.32 gm), number of seeds per fruit (58.60) and seed weight per fruit (1.06 gm).

The superiority of herbal extract treatment compared to control was attributed towards prolonged assimilation activity of leaves, as reflected on growth parameters. It appears that foliage supplied nutrients through plant extracts at appropriate growth stage of nutrients need were effectively absorbed by the plants, taking prolonged retention of leaves and more production of chlorophylls which favoured higher photosynthesis for efficient seed filling and thus enhanced yield.

Mosaic incidence was almost uniform level among the treatments before initiation of the experiment. However, significant differences were recorded after spraying the noni herbal extracts. The disease level in the noni extract sprayed field did not increase from the earlier level due to complete reduction in vector control. It was also noticed that earlier infected plants also recovered well, when compared to 100% incidence of mosaic in control plot. Plant extract have the capacity to control virus diseases by controlling the vectors reported by Singh and Korpraditskul, 1999 in chilli. Insecticidal efficacy of noni was reported by Luc Legal et al, 1994.

Conclusion

An investigation was undertaken to evaluate the efficacy of various herbal products of noni viz., Noni Ayur, Noni Vardhini and Noni Rakshak against mosaic disease and related growth and production of chilli variety Arka Lohit. Among the products Noni Vardhini was more effective both in vegetative, reproductive parameters and disease control by recording highest yield.

Recommendation

Since there is very less information on insecticidal properties of noni plant extract the present work offers valuable information on viral disease green management by vector control through herbal insecticides. Further detailed study is needed in this aspects related to the chemical constituents which is responsible for insect control in the plant, formulation and dosage of formulation etc.

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Table 1: Effect of different Noni herbal extracts on growth and reproductive parameters of chilli

Treatment	Plant height (cm)	Plant spread (cm)	No. of branches	No. of days taken for flowering after transplanting	No. of days taken for fruit setting	No. of days taken maturation of green chilli	No. of fruits per plant
Noni Vardhini	116.22	72.55	6.11	38.56	43.5	58.22	144
Noni Ayur	117.89	81.06	6.33	39.22	44.2	59.11	134.6
Noni Rakshak	108.11	70.56	5.67	40.11	45.22	59.44	126
Control	86.33	57.56	4.89	40.67	45.67	59.78	110.3
CD(0.05)	1.76	1.58	0.45	1.72	2.64	1.65	2.62
Sed	0.72	0.64	0.18	0.70	1.08	0.68	1.07

Table 2: Effect of different Noni herbal extracts on yield parameters of chilli

Treatment	Fruit length (cm)	Fruit diameter (cm)	Fresh Wt. per fruit (g)	No. of seed per fruit	Seed wt. (g)	Yield per plant (g) green chilli	Yield per plant (Quintal)
Noni Vardhini	5.32	0.64	3.32	58.6	1.06	314	135.4
Noni Ayur	4.95	0.58	2.90	56.4	1.05	310	133.9
Noni Rakshak	4.87	0.57	2.79	52.6	1.03	303	131.6
Control	4.67	0.47	1.99	32.1	0.85	190	87.44
CD(0.05)	0.19	0.03	0.02	1.35	0.05	4.79	2.54
Sed	0.08	0.01	0.01	0.55	0.02	1.96	1.04

Table 3: Effect of noni herbal extracts on incidence of mosaic disease in Chillies

Treatments	Incidence of mosaic disease		
	30 DAP	60 DAP	90 DAP
Noni Vardhini	5 (12.92)	18(25.10)	18(25.10)
Noni Ayur	2(8.13)	19(25.84)	19(27.27)
Noni Rakshak	7(15.34)	21(27.27)	23(30.65)
Control	10(18.43)	73(58.69)	100 (89.36)
CD(0.05)	1.37	0.65	1.77
SEd	0.56	0.27	0.72

Values in parenthesis are Arcsine transformed values

Studies on shelf life and biochemical changes of *Morinda citrifolia* L. (Noni) fruits during storage

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Abstract

Noni (Morinda citrifolia L.) one of the important under utilized fruit and it has been used by humankind as both food and medicine for millennia. After harvesting the noni, it become ripe within a week at ambient temperature and also because of its short storage life its fruits cannot be transported to the distant places even within the country. To regulate the marketing for the consumer acceptability and greater remuneration, it is necessary to study the storage behavior and physico-chemical changes occur during ripening of fruits of Morinda citrifolia L. Hence, the present study was carried out in Central Agricultural Research Institute, Port Blair to find out the suitable harvesting methods and to study the physico-chemical changes occurring during the storage period. The matured fruits of Morinda citrifolia L. were harvested with and without pedicel to evaluate the influence of method of harvesting on storage life of fruits. Result shows that the physiological loss of weight was highest (28.28%) in non-pedicellate fruits. Ascorbic acid and acidity content were found to be decreased in fruits during storage and the rate of reduction was slow in fruits harvested with pedicel. Maximum ascorbic acid content (115.32 mg/100 gm on 9 days after storage) was observed in fruits harvested with pedicel and minimum acidity (1.04% on 9 days after storage) was noted in fruits harvested without pedicel. Highest percentage of spoilage was recorded in fruits, which harvested without pedicel (50%). TSS content was increased during ripening; the rate of increase is low in fruits harvested with pedicel and the highest TSS content (10.68o Brix) also observed in fruits with pedicel. Results revealed that Morinda fruits harvest with pedicel maintaining better storage quality and market acceptability.

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Introduction

Morinda citrifolia L. has high medicinal values. After harvesting the noni fruits, it becomes ripened within a week at ambient temperature and also because of its short storage life its fruits cannot be transported to the distant places even within the country. To regulate the marketing for the consumer acceptability and greater remuneration, it is necessary to study the storage behavior and physico-chemical changes occur during ripening of fruits of *Morinda citrifolia L.* In India noni fruits are harvested by hand. Hand picking has proved superior method of harvesting in terms of quality and decay control over traditional harvesting by shaking the branches (Yagi et al., 1978). Longer shelf-life of pear and stone fruits namely, plum and mango has been recorded when plucked along with small pedicels (Fuchs and Barki-Golan, 1979, Prakash et al., 1996 and Singh et al., 1993). Since research data are not available as to the effect of fruit pedicel on storage behaviour of *Morinda citrifolia*, a highly perishable and delicate underutilized fruit having a poor shelf-life. Keeping the above facts, the present investigation was undertaken to find out the effect of harvesting methods and to study the physico-chemical changes occur during the storage period of *Morinda citrifolia L.*

Materials and Methods

The experiment was conducted in Horticulture and Forestry Division, Central Agricultural Research Institute, PortBlair. The selected full-grown trees of *Morinda citrifolia* had been maintained under standard cultural conditions. Well matured fruits of *Morinda citrifolia* free from damage and bruises were selected. These uniform matured fruits were harvested by two different methods viz., fruits harvested with pedicel and fruits harvested without pedicel. The harvested fruits were washed and shade dried until no water visible on the fruit surface. The fruits were stored under ambient condition. The experiment was laid out in completely randomized block design with two treatments, 15 replications and 10 fruits per replication. Observations were noted on three days interval up to last day of storage. The physiological loss of weight (PLW) was determined by calculating the loss in fruit weight during storage over initial values. The percent decay losses were recorded on the basis of number of fruits rotted on each date during storage. TSS was determined by hand refractometer and expressed in °Brix, the acidity and ascorbic acid levels in fruits estimated by AOAC method (AOAC, 1989).

Result and Discussion

The investigation on the effect of different methods of harvesting, storage behaviour and physiochemical changes in *Morinda citrifolia L.* gave significant results. The data presented in Table 1 clearly suggest that the fruits harvested with pedicel recorded the lowest physiological loss of weight (23.13 %) when compared to the fruits harvested without pedicel (28.28%). Moisture loss through transpiration during storage affects the salable weight and eventually the fruit becomes unsalable as a result of wilting (or) shrinking. Physiological loss of weight was continuous phenomena during storage due to moisture loss (Salunkhe, 1984). During the fruit ripening process, total carbohydrates are converted into total soluble sugar some of them are further metabolized through respiration and lost as CO₂. This could be the reason for PLW. The percent physiological loss in weight and decay loss were higher in fruits without pedicel. These results are in close conformity with those of Pathak and Srivastava (1969), Desai (1994), Prakash *et al.* (1996) and Singh *et al.* (1993) who had recorded maximum rotting and fruit weight loss in mango, grape berries, pear and plum fruits plucked without pedicel owing to exposed surface of pedicel.

‘The results reported here (Table 1) indicate that decay percentage of fruits increased with increasing storage period in both the treatments. Spoilage might be either due to microbes or CO₂. Disease infection in fruits was not observed upto three days after storage in both the treatments. Later onwards, resistance to pathogen entry was decreased. Less decay percentages of 25% and 40% were observed in fruits harvested with pedicel on 6 and 9 days after storage respectively whereas highest spoilage percentage of 50% and 60% was observed in fruits harvested without pedicel on 6 and 9 days after storage respectively.

The fruit pedicel did not significantly influence chemical composition of fruit in terms of TSS and acidity. The changes brought about in total soluble solids of fruits during ripening are mainly due to degradation of starch and accumulation of sugars. Fruits harvested with pedicel showed a marked effect on the rate of carbohydrate metabolism and the concomitant changes in TSS. The gradual increment in TSS was observed in fruits harvested with pedicel. The highest TSS of 10.68°Brix was observed in fruits, which are harvested with pedicel and lowest TSS of 10.18 °Brix was recorded in fruits harvested without pedicel.

Ascorbic acid content of fruits decreased gradually during storage. Lowering ascorbic acid content could be related to the activity of ascorbate oxidase, which promotes the oxidation of ascorbic acid to dehydroascorbic acid. The rate of reduction of ascorbic acid during storage was low in fruits which are harvested with pedicel. The highest ascorbic acid content of 16.77 mg/100gm was observed on six days after storage in pedicellate fruits whereas minimum ascorbic acid content of 14.42 mg/100gm was observed on six days after storage in non-pedicellate fruits.

Acidity content of fruits decreased with increasing period of storage in both the treatments. The acidity content gradually decreased during advancement of storage period in pedicellate fruits. The lowest acidity content (1.04%) was noticed in pedicellate fruits and the highest acidity (1.27%) was recorded in non-pedicellate fruits. The titrable acidity during storage might be converted into sugars and their derivatives are used in respiration and this may be the reason for decreasing trend of acidity towards ripening (Singh, 1988). These results confirm the findings of Prakash *et al.* (1996) and Singh *et al.* (1993) who had also recorded similar results in pome and stone fruits harvested with stalks. This was probably because of minimum PLW, slower rate of evaporation and respiration due to less utilization of organic acids.

Careful harvesting of noni fruits is important for maintaining transportability, quality and shelf life. Generally the noni fruits are harvested without pedicel. So the fruits are susceptible to the diseases. The fruits with and without the pedicel had a similar behaviour in relation to the chemical composition, but the fruits without pedicel got rotten early while the fruits with the pedicel remained a condition suitable for marketing until nine days after storage. The manual removal of the pedicel causes a mechanical injury that makes the fruits susceptible to infestation, accelerating the ethylene production and consequently resulting in an early senescence. Tingwa and Young (1975) showed that removing the pedicel increased the rate of ripening in avocados in California.

Conclusion

Methods of harvesting of noni, storage behaviour and physico chemical changes during the storage of noni fruits were studied in the present investigation. The results proved that the fruits harvested with pedicel can perform well under storage and recorded increased shelf life.

Due to absence of proper post harvest management system, bulk quantity of noni gets damaged during the process of handling, transportation and marketing. Moreover the fruits are harvested either in proper stage and method of harvesting which further influences the shelf life of the noni besides its quality. Therefore a detailed study on the post harvest management of noni is very much essential.

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Table 1: Effect of method of harvesting on physico-chemical changes of *Morinda citrifolia* fruits during storage

Days harvest	Physiological loss of weight (%)		Ascorbic Acid Content (mg/100gm)		Acidity (%)		TSS (^o Brix)		Percentage of Decay (%)	
	Fruit with pedicel	Fruit without pedicel	Fruit with pedicel	Fruit without pedicel	Fruit with pedicel	Fruit without pedicel	Fruit with pedicel	Fruit without pedicel	Fruit with pedicel	Fruit without pedicel
0 DAS	0.00	0.00	24.86	24.86	1.04	1.04	8.40	8.40	0.00	0.00
3 DAS	7.68	8.82	21.25	17.75	0.76	0.74	10.02	10.18	0.00	0.00
6 DAS	17.41	18.94	16.77	14.42	0.70	0.67	10.35	10.04	25	50
9 DAS	23.13	28.28	15.32	10.66	0.53	0.50	9.54	9.00	40	60
CD (0.05%)	1.80	0.55	0.74	0.52	0.07	0.06	0.10	0.13	2.89	2.77
S.Ed	0.78	0.24	0.32	0.22	0.03	0.02	0.04	0.06	1.25	1.20

Table 2: Influence of method of harvesting on shelf life days of Different accessions of Noni fruits

Accessions	Shelf life (days)			
	Matured fruits		Ripe fruits	
	With pedicel	Without pedicel	With pedicel	Without pedicel
GAH	9.5	8.5	6.5	5
SPG	9	8.5	6	5
MEM	9.5	7.5	6.2	5.3
WAND	9.9	7.9	5.5	5
JGH	9.8	7.5	5.8	5
HD	9.5	8.5	6.9	5.7
PBAY	9	8	6	5.5
CD(0.05%)	0.32	0.47	0.30	0.27
S.Ed	0.15	0.22	0.14	0.12

Table 3: Influence of method of harvesting on physiological loss of weight of different accessions of Noni fruits.

Days after Storage	Physiological loss of weight (%)													
	GAH		SPG		MEM		WAND		JGH		HD		PBAY	
	with pedicel	without pedicel	with pedicel	without pedicel	with pedicel	without pedicel	with pedicel	without pedicel	with pedicel	without pedicel	with pedicel	without pedicel	with pedicel	without pedicel
3 DAS	0.05	1.25	0.06	1.40	1.70	1.99	0.14	1.41	0.75	1.01	0.06	1.44	0.48	0.73
5 DAS	1.63	2.70	1.25	2.39	2.27	2.91	3.68	4.85	1.14	3.80	0.56s	2.58	2.66	3.18
7 DAS	3.35	8.655	2.63	3.15	5.47	7.93	5.85	9.38	3.76	5.15	1.37	5.04	3.68	5.42
9 DAS	3.81	13.26	2.90	9.70	9.07	10.31	10.64	—	—	—	3.76	6.93	3.74	6.38
CD (0.05%)	0.08	0.14	0.07	0.21	0.13	0.09	0.34	0.14	0.42	0.19	0.14	0.12	0.12	0.13
SEd	0.03	0.06	0.03	0.09	0.06	0.04	0.15	0.06	0.18	0.08	0.06	0.05	0.05	0.06

***Morinda citrifolia* L., (Noni) – A viable alternative for Tsunami affected agricultural lands**

D.R.Singh¹, R.C.Srivastava* and R.Raja¹

Abstract

*It was a big challenge for the scientists for identification of suitable economic plants, which can be grown in these affected areas. It has been reported that, Noni (*Morinda citrifolia* L.) is a highly salt tolerant tree that thrives in wet or dry conditions. There is a membrane enclosing a gel – like substance around each seed enabling flotation, and the seed coating, being very hard and air/water tight, can delay sprouting for many months. The flower is self-pollinating; so only one seed needs to sprout for a successful population to possibly emerge. These are positive traits for sea or air dispersal and colonization in any harsh condition, from salt flats to lava flows, therefore a series of experiment were conducted in a variety of range of salinity to observe its influence on growth and yield of Noni. The results revealed that Noni could grow upto an EC level of 13.5 dSm⁻¹ with normal flowering and fruiting while the plant exhibited tolerance upto an EC level of 21.3dSm⁻¹. Hence, Noni has emerged as an important alternative crop in Tsunami affected areas of A & N Islands. Since this plants tolerates high salinity, and tolerant of ocean salt spray the farmers of the coastal regions may be advised to take up its plantations commercially in large scale in saline area and also in the tsunami affected land. As Noni is tolerant of extreme salinity in general and is thought to possibly gain nutritional benefit from the minerals contained in seawater. In this way this plant play a vital role in giving boost to the economy to the growers and unused land will be made useful by giving clean green environment.*

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Key words : Salinity, seawater, seedlings, salt stress

Introduction

Natural disasters such as Earthquakes, *Tsunami*, Cyclones, Floods, etc., are well known for their devastating impacts on human life, economy and environment. With tropical climate and unstable land forms, coupled with high population density, poverty, illiteracy and lack of infrastructure development, developing countries are more vulnerable to suffer from the damaging potential of such disasters. The massive earth quake of 9.2 magnitude on the Richter scale which hit Indonesia (of the west coast of the Northern Sumatra) on the morning of 26th December 2004 was the biggest in 40 years. This triggered massive *Tsunami* waves, which has created havoc and excessive devastation in terms of human lives and loss of infrastructures in coastal areas of Andaman and Nicobar Islands. The coastal areas of these Islands affected by the *Tsunami*, present highly diversified human activities, from inland fresh water rice-based systems to mangrove and coastal strips used primarily for fishing. Seawater ingression due to *Tsunami* waves has lead to the complete submergence of adjoining paddy fields and other plantations and resulted not only in crop loss but also drastically changed the soil properties and increased the soil salinity to a much greater level than the pre-*Tsunami* level. After *Tsunami*, three different situations viz., ***(i) where sea water only intruded during Tsunami and receded completely, (ii) Sea water intrudes during high tide and recedes during low tide and (iii) coastal areas where there is permanent stagnation of sea water and depth of impounding increases with high tide*** prevailed in Andaman & Nicobar Islands. So, the farmers of A & N Islands are facing a situation in which they have either lost their farmland completely or to deal with the problem of soil salinity.

In saline soil, crop growth is hampered by salt accumulated in the root zone. Salt in the soil interferes with the crop growth when its concentration exceeds the tolerance limits of the crop (Somani, 1991). Most plants suffer salt injury at concentration equivalent of EC of soil saturation extract of 4 dSm⁻¹ or higher. At such a level of salinity, plant growth is restricted even though enough water may be present in the root zone. However, this presents an opportunity to use of salt tolerant plants of economic importance. Recent research findings

have identified *Morinda citrifolia* L. (Noni) as one of the miracle plant, which tolerates salinity and grows in all types of well-drained soil. These halophytic plants adapt well in salty solution environments through altering their energy metabolism (Winocov and Batsola, 1997). It requires water during early stages of crop for better growth and development. Noni grows in very wide range and environments with notable ability to survive in harsh environment, such as those found on coral atolls or basaltic lava flows. Noni tolerates a wide range of drainage conditions including seasonal water logging. It can grow in a wide range of pH levels, from acidic to alkaline and can tolerate shallow, saline, sodic and infertile soil environments. It can be found naturally in disturbed forests, alien grasslands, open areas near the shoreline, pastures and coconut plantations, littoral forest, fallow areas and in wastelands (Cambie and Ash, 1994). Mature cultivated Noni tree can easily tolerate drought for more than six months (Nelson, 2005). It can tolerate a high level of pH and EC, beyond 9 and 30 dSm⁻¹ respectively (Singh *et al.*, 2006). It is an underutilized fruit tree but an important food source for the rural people. The fruits are eaten fresh, processed into drinks in the form of health tonic. The species are found in natural woodlands, agro forestry systems and home gardens. They are often used as windbreakers or as boundary markers in the agricultural area.

Materials and Methods

Seeds of *Morinda citrifolia* were obtained from a mother tree grown in a wild stand. Twenty seedlings of four month old were selected for uniformity and planted in pots filled with media (Red soil, compost, sand 2: 1 ratio). After allowing one-week as adaptation period for the seedlings, the seawater irrigation was initiated with different treatments viz., S₀ (100% fresh water); S₁ (25% seawater + 75% normal water); S₂ (50% sea water + 50% normal water); S₃ (75% sea water + 25% normal water) and S₄ (100% seawater). The EC of the seawater and media used for the experiment were 17 and 0.07 dSm⁻¹, respectively. The experiment was carried out in the polyhouse of the Division of Horticulture and Forestry, Central Agricultural Research Institute, Port Blair in a random block design with four replication, for one year. Initially upto 10 weeks, the seedlings received 100 ml every second day and there after the seedlings received 100ml per week. The growing conditions were 30°C/25°C (day/night) air temperature and 70 % (± 10%) RH.

Simultaneously to assess the impact of tsunami on the agricultural lands, extensive survey cum soil sample collection was done immediately after tsunami and six months after tsunami in the *Tsunami* affected areas of South Andaman *viz.*, *Lalpabar, Craikabad, Mitba Khari and Guptapara*. The samples were collected from surface layer (0-15 cm) and subsurface layer (15-30 cm) using mann corer (7cm Ø, 60 cm length) from ten selected spots by making a transect walk across the slope under each of three different situations as discussed elsewhere. The soil samples were air dried, powdered with wooden mallet and sieved through a 2 mm sieve. The sieved samples (< 2 mm) were analyzed for pH and EC by using pH and EC meter using standard methods (USSL STAFF, 1954). The results were discussed here under.

Results and Discussion

Effect of seawater irrigation on Noni

During the 20-week long treatment period, there was only slight defoliation in the *Morinda* plant, which receives 100% seawater irrigation (S_4). According to Jens Gebauer *et al.*, 2005 remarkable defoliation in the salt stressed baobab plants was observed leading to an enormous difference in the leaf area between control and treatments. During the treatment period slight leaf injury symptoms were observed mostly on mature leaves. This is because of the preferential accumulation of Na^+ and Cl^- ions in basal (older) rather than apical (younger) leaves (Sykes, 1985; Bonggi and Lorento, 1989 and Munns, 1993). Salinity has much less effect in shoot elongation in all treatments after the 20-week treatment. Reduction of dry weight by the salt treatments was much lower in *Morinda citrifolia L* seedlings. It was less than 50% after the 20 weeks in comparison to the control plants. The effects of different levels of seawater irrigation on the growth of *Morinda citrifolia* are discussed below with the following results:

Plant height

Effect of seawater irrigation on plant height did not exhibit significant variation between the treatments on 30 DAP. The height of the plants at 360 days after planting ranged from 51.6cm (S_2) to 62.5cm (S_4). The maximum height was recorded in plants irrigated with 100% seawater followed by 53.1 (S_1 - 25% seawater). This suggested that *Morinda citrifolia*

is able to put on good vegetative growth in terms of plant height even on irrigation with 100% seawater. The plants that grow in saline soils have diverse ionic compositions which vary according to the changes in water source, drainage, evapo-transpiration and solute availability and a range in concentrations of dissolved salts (Volkmar *et al.*, 1998) and thus the plant growth depends on a supply of inorganic nutrients, and this level of nutrients varies in time and space (Maathius and Amtmann, 1999). When soil salinity exceeds a plant's tolerance, growth reductions occur (Hayward *et al.*, 1958.). Salinity resistance is a quantitative trait, and it has been resistant to plant breeding (Winicov, 1998).

Girth of the plant

There was no significant variation among the treatments in terms of its girth also. The plants irrigated with 100% (S_4) and 75% (S_3) seawater recorded highest girth than the plants irrigated with normal water (S_0) (Table3).

Number of leaves

Slight variation exhibited between the treatments for the number of leaves. Plants irrigated with 100% sea water (S_4) exhibited the lowest number of leaves (31) at 360 DAP whereas 50% sea water (S_2) recorded highest (35) number of leaves at 360 days after planting followed by 75% (34) and control (33). The reduction in the number of leaves indicated slow growth rate attributed due to the salt accumulation in the soil resulted from seawater irrigation.

Nutrient composition in leaves

Accumulation of calcium in the leaves of *Morinda citrifolia* was found more on plants irrigated with 75% seawater (S_3) (539.2ppm) followed by plants with 100% (S_4) (536.7ppm); 25% (S_1) (520.8ppm) and 50% (S_2) (484.5ppm) respectively. According to Serrano *et al.*, (1999)--- the irrigation water contains calcium, magnesium and sodium, which transpire when water evaporates and transpires leaving sodium dominant in the soil. High K^+/Na^+ selectivity in plants in the presence of high external Na^+ is strongly facilitated by the external Ca^{2+} concentration (Lauchili, 1990). No significant variation was observed among treatments with respect to content of Magnesium i.e., highest content (50.7ppm) was recorded in 50% seawater followed by 50.7ppm in 25% seawater and lowest (49.8ppm) in 100% seawater.

Among the micronutrients, iron content was higher (271ppm) in 50% followed by 75% (185ppm) and lowest (84 ppm) in 25% seawater. Copper content was higher (7.6ppm) in 25% (S_1) and lowest (4.6ppm) in 75% (S_3) seawater. This signified the potential of the plant to withstand salinity up to 100% irrigation of seawater.

Soil salinity status of tsunami affected agricultural lands

The analytical results of the soil samples of above said soil series collected immediately after *Tsunami* and six months after *Tsunami* have been given in Table 5. Under Situation I, the pH of surface soil (0-15 cm) was varying between 4.7 and 7.6 and EC was varying between 3.9 and 16.6 dSm⁻¹ which indicates that there were lot of changes in hydrogen ion concentration and soluble salt content in the soil. Under Situation II and Situation III, the results revealed that irrespective of locations, the EC of surface soil (0-15 cm) has increased in the range of 11 to 23.2 dSm⁻¹. The increased level of soluble salt concentration in the sub surface has resulted in increased soil salinity where the EC ranged from 4.1 to 14.5 dSm⁻¹. The reason for this may be attributed to the large volume of sodium and other soluble salts left on the surface soil by frequent intrusion or permanent stagnation of seawater in the field. In case of sub surface soil, the increased level of salinity may be due to the percolation of soluble salts down ward from the surface soil. The results clearly indicated that in most of the places, the soil salinity level has increased > 4 dSm⁻¹ immediately after tsunami, both in surface and subsurface layers and after six months it has slightly decreased but stayed above 4 dSm⁻¹.

Conclusion

The salinity level of tsunami affected agricultural lands especially the lands under situation II is beyond the tolerant limit of most of the agricultural crops. This necessitates adoption of alternate land use strategies like use of salt tolerant plant species having better economic importance for effective utilization of this tsunami affected agricultural lands. With the inherent salt tolerance and higher economic value, Noni picks up itself as the best alternative for these tsunami affected lands.

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Table 1: Effect of sea water irrigation on height of Noni at different stages

Treatment	Plant height (cm) (DAP)											
	30	60	90	120	150	180	210	240	270	300	330	360
S₀ (Control)	21.3	24.0	24.5	27.8	29.2	29.5	29.7	29.8	29.9	30.0	30.0	34.4
S₁	20.0	21.9	24.0	26.8	28.5	31.5	34.8	39.7	45.1	47.9	50.6	53.1
S₂	20.3	21.9	24.4	26.8	27.8	29.0	29.5	35.0	41.1	43.6	46.0	51.6
S₃	21.6	24.6	24.5	25.6	34.5	34.9	35.1	40.7	43.5	45.9	47.9	51.8
S₄	23.8	27.0	29.1	30.4	33.8	34.0	34.8	43.1	48.3	53.4	57.4	62.5
SEd	0.61	0.63	0.69	0.64	0.53	0.87	0.81	0.89	1.10	0.52	1.04	0.52
CD (P=0.05)	2	1.46	1.58	1.49	1.22	2.01	1.88	2.06	2.54	1.19	2.41	1.19

Table 2: Effect of sea water irrigation on number of leaves of Noni at different stages

Treatment	Number of leaves (DAP)											
	30	60	90	120	150	180	210	240	270	300	330	360
S₀ (Control)	15.6	18.0	20.0	20.0	20.0	17.3	17.3	17.3	23.0	23.0	24.5	32.7
S₁	24.7	16.0	18.7	18.7	18.7	19.0	19.5	22.0	22.0	26.3	30.1	33.1
S₂	13.6	15.2	17.3	17.3	17.3	18.7	19.0	25.0	26.0	31.7	32.7	35.0
S₃	13.6	14.4	17.3	17.3	17.3	18.0	18.0	25.0	26.0	31.3	32.7	33.7
S₄	16.0	13.6	16.0	16.0	16.0	17.3	17.3	24.0	24.0	26.7	27.5	30.7
SEd	NS	0.85	0.21	0.20	0.22	0.22	0.26	0.26	0.86	0.88	1.79	0.72
CD (P=0.05)	NS	1.96	0.49	0.47	0.53	0.53	0.60	0.60	1.98	2.04	4.14	1.67

Table 3: Effect of sea water irrigation on stem girth of Noni at different stages

Treatment	Stem girth (cm) (DAP)											
	30	60	90	120	150	180	210	240	270	300	330	360
S₀ (Control)	0.26	0.38	0.48	0.50	0.46	0.50	0.50	0.53	0.53	0.53	0.53	0.53
S₁	0.22	0.32	0.42	0.44	0.46	0.46	0.50	0.53	0.53	0.53	0.53	0.60
S₂	0.26	0.32	0.48	0.48	0.48	0.48	0.50	0.50	0.53	0.53	0.53	0.60
S₃	0.26	0.38	0.40	0.46	0.50	0.50	0.50	0.53	0.60	0.63	0.63	0.66
S₄	0.30	0.40	0.50	0.50	0.53	0.53	0.53	0.60	0.60	0.70	0.70	0.70
SEd	NS	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.02	0.03
CD (P=0.05)	NS	0.04	0.05	0.04	0.06	0.03	0.05	0.05	0.02	0.06	0.04	0.07

Table 4 : Nutrient composition in *Morinda citrifolia L*(leaves) irrigated with different concentrations of sea water.

Treatments	Concentration (ppm)			
	Ca	Mg	Fe	Cu
S₀ (Control)	5462	570.6	4.5	2.2
S₁	520.8	50.7	83.6	7.6
S₂	484.5	50.7	271.1	4.5
S₃	539.2	50.2	185.1	4.6
S₄	536.7	49.8	182.4	4.4
CD(0.05%)	52.69	5.46	3.34	0.20
SEd	23.64	2.45	1.50	0.09

Table 5: Soil pH and EC of *Tsunami* affected agricultural lands of South Andaman

Location	Situation	Soil pH <small>(1: 2 soil: water)</small>				EC <small>(1: 2 soil: water) (dSm⁻¹)</small>			
		(0-15 cm)		(15-30 cm)		(0-15cm)		(15-30cm)	
		ST ₁ [‡]	ST ₂ ^{‡‡}	ST ₁	ST ₂	ST ₁	ST ₂	ST ₁	ST ₂
Lalpad	I	6.5	5.9	6.7	6.1	11.9	4.8	5.4	4.1
Crikadabad		7.6	6.6	7.6	5.5	13.7	4.0	4.5	5.3
Mithakari		5.9	6.8	6.1	6.5	16.6	10.4	8.8	7.2
Guptapara		4.7	5.5	5.6	5.7	3.9	0.4	1.1	1.0
Lalpad	II	7.0	6.6	6.4	6.5	20.8	12.1	11.7	9.2
Crikadabad		7.5	6.4	7.5	4.8	20.3	4.2	8.2	5.1
Mithakari		5.8	6.3	5.6	5.8	23.2	11.2	14.5	10.3
Guptapara		4.8	5.0	5.1	5.1	12.6	1.2	4.2	1.4
Crikadabad	III	7.6	5.8	7.6	6.0	13.2	4.1	4.1	4.2
Mithakari		4.8	6.1	4.0	6.2	14.6	7.7	7.9	5.6
Guptapara		4.7	5.1	4.7	5.2	11.0	2.2	5.3	2.6

[‡] ST₁: Sampling Time 1 (Soil samples collected immediately after *Tsunami*)

^{‡‡} ST₂: Sampling Time 2 (Soil samples collected six months after *Tsunami*)

Need and Scope for Evolving Holistic and Organic Crop Protection Options for Noni (*Morinda citrifolia. L.*)

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Abstract

The knowledge base on spectrum of current and potential insect pests and diseases of Noni (*Morinda citrifolia*) in India and in Asia as a region needs to be strengthened. This calls for focussed surveys in the major agro-ecologies suited to noni cultivation and bio-ecological studies. The crop protection technology options should be so chosen as to comply with for organic farming principles and to also ensure that the produce and products are safe for human consumption. The technology options should also be compatible with the crop ecosystem and help preserve the beneficial native agro-biodiversity. Research and development (R&D) programs should evolve holistic control packages for the current priority pests and diseases and also focus on futuristic strategies for handling potential problems. Selective deployment of adapted native strains of the promising bio-control agents- predators, parasitoids and pathogens- and improving the formulations and optimizing the application of bio pesticides should be taken up. Chemical ecology knowledge on attractants/lures should be availed for improved use in trap systems for monitoring and mass trapping of pest insects. The scope for utilizing induced systemic resistance/tolerance to pests/diseases through endophytic associations and nutritional means should be fully evaluated. There is need for local capacity building among practitioners for correct diagnosis and prompt control guidance. The scope for evolving a consortium approach for R&D linkages and networking for Integrated Pest Management (IPM) approach, with focus on organic crop protection technology options is discussed.

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1. Introduction

Noni (*Morinda citrifolia*) is emerging as a potentially important horticultural and medicinal plant in the Indian subcontinent, being a source of a wide range of nutraceuticals of great utility in promoting human wellness (Kirti Singh, 2007; Mathivanan et al., 2005; Mathivanan and Surendiran, 2007; Peter, 2007a; b; Rethinam, 2007). The crop is being promoted for technically supervised cultivation system, in contrast to utilizing the fruits harvested from wild stands, such as those occurring in Kerala and Andaman . Our current knowledge on pests/diseases of noni is largely limited to the research work in Hawaii (Nelson and Elevitch (2006) and there is very little local information available in India and elsewhere in Asia. We need to organize systematic surveys across the emerging noni farms so to capture the temporal and spatial patterns of their occurrence. Also it is necessary to identify critical gaps in our knowledge on bio-ecology and organic management of pests/diseases on noni and to suitably focus on them as priority in our future noni R&D in the region.

1.1. Bioecology, survey and monitoring of pests/diseases

As a starting point, a listing of groups of pests and diseases based mainly on the work of Nelson and Elevitch (2006) (Table 1), could be used for further additions and deletions, so to relate more closely to the situation in the Indian subcontinent. should be pursued for ecological characterization of different common pests/diseases. We should pursue bio-ecological studies on the important and common pests/diseases, which occur locally, like the tinged bug, *Dulunius conchatus* on *Morinda pubescens* (= *M. tinctoria*) (Dhanasekaran and David, 2007) .Our focus should be to undertake ecologically-focused and systematic surveys to determine the pest/disease spectrum on the crop in India and elsewhere in Asia. An illustration of the potential knowledge gains from such effort is provided from a very recent survey undertaken in Kerala, South India mainly in noni natural stands during 2005-07 (Mathivanan, 2007), on the arthropods pests, natural enemies and pollinator insects in noni ecosystems (Table 2), besides assembling similar information on locally occurring noni diseases (Table 3).

We need to use these initiatives to build baseline information on the temporal and spatial dynamics of major pests and diseases through systematic monitoring and surveys across the noni growing regions in India. We should also evolve an easily quantifying yet not laborious monitoring system, so to build base-line data on the spectrum of pests and diseases occurring on noni and its closely related species in different agro-ecological regions and across the seasons in the year. Similar efforts should be made to monitor and survey for the other biotic stresses, including pathogens plant parasitic nematodes.

1.2. Pest grouping for monitoring and severity assessment methodology

Noni, being a relatively less researched horticultural and medicinal crop, there is need to develop appropriate sampling strategies for the major pests and diseases. Initially, the following groups could be focused upon :

- i. Defoliating pests or foliar diseases
- ii. Foliar sucking pests or insect-motored diseases.
- iii. Internal feeders in leaf/stem or stem diseases.
- iv. Fruit/flower infesting pests or pre & post harvest diseases.
- v. Soil dwelling pests & nematodes or soil borne diseases

We need to determine the intra-plot and intra-plant minimum sample sizes, based on standard statistical methodology. Where appropriate, correlations/regression to be worked out among the quantitative attributes of incidence (abundance/density) of pests/diseases versus the extent of damage in the concerned plant part. It is important to develop visual rating scales for assessing the relative severity of incidence/damage for individual pest groups for periodical monitoring versus for evaluating different control methods/options in field trials. This should be a priority R&D theme, since it will help in appropriately and uniformly documenting the results of field evaluations/monitoring/surveys.

1.3. Timely and correct diagnosis system

There is no need to over-emphasize the importance of timely detection of the problem and correct identification of the causal agent (pest, disease, and nematode), as key for securing prompt and appropriate remedial intervention. Noni farmers and practitioners should be

trained in symptom detection and recognition of major life stages of pests in the crop. Such initiative should also cover the knowledge of beneficial insects like predators, parasitoids and pollinators, which would require protection/conservation. Cultivators should be made aware of the benefits of regular crop inspection as means for early detection. Farmers' groups may be assisted with participatory learning of correct diagnosis through the Farmer's Field School (FFS) approach.

2. Organic cultivation and appropriate pest control

Noni cultivation is expected to be sustained through adopting organic principles of farming. The importance of organic cultivation of noni and the scope for utilizing farm-derived organic inputs for crop production in India has been recently pointed out (Palanichame, 2007; Pathak and Ram, 2007). The potential areas for extended cultivation of organic noni and its usefulness as a livelihood crop in tsunami-prone lowland areas, especially in Andaman Islands of India have been recently documented (Singh et al., 2006a; b; 2007a: b; Surendiran and Mathivanan, 2006; Subhash Chand and Singh, 2007).

As a starting point for organic crop protection R&D, we could visualize the range of options that could be tested/developed for the different known insect pests of noni (Table 4) and also similarly for the diseases (Table 5). As such, there is need and opportunity to demonstrate the benefits from adopting suitable organic practices and to standardize the application of organic crop protection inputs, so as to enable noni growers to adopt appropriate and compliant pest control.

2.1. Biodiversity of the beneficial biota in the ecosystem

It is highly appropriate that the Indian National Biodiversity Authority (NBA) is stimulating and guiding agro-bio diversity R&D, besides awareness building on conservation and sustainable use of native bio-diversity in agro-ecosystems. Sithanatham et al. (2006) proposed a strategy for capturing the native diversity of natural enemies of pests, especially among those which have potential for use in augmentative biocontrol of major insect pests in India. Such biodiversity surveys for beneficial natural enemies of pests and diseases could be undertaken in linkage with plant bio-diversity surveys/studies being undertaken on Noni (Morton, 1992; Singh et al., 2007a; b). This will permit us to concurrently assemble, identify, characterize

and selectively conserve such beneficial micro-flora and micro-fauna (parasitoids, predators, entomopathogens), which could more effectively suppress the key pests and diseases, and so can be used for enhancing the biological control impact as a major component of organic crop protection for Noni.

2.2 Stronger Noni Plants to withstand Pest/Disease Attack

Organic farming, with emphasis on organic manures, can itself contribute to enhancing the capacity of Noni plants to tolerate pest/disease attack. This could be similar in approach to a recent study on sugarcane borers in Tamil Nadu, India, wherein repeated application of organic manures was found to exert comparable control of the internode borer, to that of a full set of IPM practices, leading to enhanced yield and crop produce quality. In addition, another dimension in R&D should be to identify pest/disease tolerant genotypes/varieties of noni, which have good agronomic qualities, and can give optimum yield, in spite of pest/disease incidence.

2.3 Use of plants with pest/disease control properties

While there is considerable volume of grey literature and indigenous traditional knowledge (ITK), we have only limited authentic publications available on native plant species which are claimed to have pest/disease control properties. No doubt, organic noni cultivation can incorporate the local cultivation/collection of such plants, as cost-reducing and organic pest/disease control options. Nevertheless, there is need to sift between 'real' and 'assumed' effects of such plants, from among the extensive and diffuse domain of traditional knowledge and demonstrate the efficacy against important noni pests/diseases. Krishan Chandra *et al.* (2006) have listed the plants which are known to be useful in pest control (Table 6). An important step should be to identify the active constituents and their mode(s) of action, besides establishing the appropriate dose rates to be used.

2.4. Crop protection technologies to integrate with crop management

As means of quick and semi-quantitative assessment of the relative incidence levels (abundance, density) of the pests/diseases and/ or the relative extent (severity/intensity) of damage, visual rating systems should be developed. These can be standardized in 1-5 or 1-9

scale as required for routine crop surveys as well as for control technology evaluations. The sampling strategy should be also standardized- both at intra-plot and at intra-plant levels, including indicator leaf/branch.

3. Way forward in Crop Protection R&D

The research and development of organic crop protection technologies for noni should focus on verification, standardization and fine-tuning of organic products and practices, so to ensure consistent and sustainable impact on the crop health. Preventive management strategies should take priority over curative control, backed by *in situ* monitoring and early warning of pest/disease build up. Research should equally focus on current problems as well as future scenarios like pest/disease invasion, eco-regional strain/population differentiation, and shifts from associated crops and weeds. Due attention should be paid to exploitation of Induced Systemic Resistance (ISR) (Marimuthu and Nakkeeran, 2007), and also to identify beneficial crop associations like intercrops/companion crops, besides promoting canopy management strategies for minimizing pest/disease build-up. Collection, selection and deployment of climatically adapted natural enemies of major pests should be emphasized for enhancing the impact in biological control. Development of appropriate pre- and post-harvest disinfestations and other preventive interventions is a critical area of R&D to assure healthy fruits and consumer-acceptable quality standards for the products.

3.1 Scope for International R&D Collaboration

Preventing the spread of invasive pest species to new areas, such as in South Asia, could be a useful network thrust, to be achieved through linking with quarantine organizations of countries in the Pacific-Australasia regions. Regional cooperation for capacity building among national regulatory personnel to correctly identify potential pests/diseases, possibly with FAO regional offices and international experts facilitating this activity would be very welcome. In particular, the expertise and experience available in the Pacific Communities coordinated by their Secretariat and regional offices and in such island territories as in Hawaii, Tahiti, Fiji plus the supportive research in Australia/ New Zealand/Europe/USA would be valuable for establishing regional scientific and regulatory collaboration network focused on promoting preventive crop protection for noni.

3.2 Importance of networking in crop protection R&D

The emerging strides in several related disciplines like molecular biology, biotechnology, chemical ecology, agro-climatology, and modeling and population ecology could be selectively and beneficially integrated into crop protection R&D for Noni. Towards this end, there is ample scope for establishing multi-disciplinary task teams with inter-institutional R&D networking, for promoting collaboration and synergy, so to maximize the efficiency of R&D with quicker and more holistic outputs. A chain of gene-banks/repositories for enabling easy and ready access to promising strains/species of bio-control agents should also be a feature of such networking involving countries and territories across the major agro-ecologies in which noni cultivation is being promoted.

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Table 1: List of known groups of pests and diseases on *Morinda citrifolia* @

Insect Pests/mites/animals	Pathogens/nematodes
<p>1. Defoliating Pests</p> <p>1.1 Croton Caterpillar (<i>Achaea</i>)</p> <p>1.2. Cotton leaf worm (<i>Spodoptera</i>)</p> <p>1.3. Grasshoppers*</p> <p>1.4. Flea beetles*</p>	<p>1. Foliar Diseases</p> <p>1.1 Algal leaf spot (<i>Cephaleurus</i>)</p> <p>1.2. Anthracnose (<i>Colletotrichum/ Glomerella</i>)</p> <p>1.3. Shot hole (<i>Guiganardia</i>)</p> <p>1.4.Sooty molds (several species)</p>
<p>2. Sucking Pests</p> <p>2.1 Aphids (<i>Toxoptera, Aphis</i>)</p> <p>2.2 Thrips (<i>Heliothrips</i>)</p> <p>2.3. White flies (<i>Dialeurodes/Aleurodicus</i>)</p> <p>2.4. Scale Insect (<i>Coccus</i>)</p> <p>2.5. Mealy bugs*</p> <p>2.6. Mites (<i>Polyphagotarsonemus, Eriophiid</i>)</p>	<p>2. Stem/Fruit diseases</p> <p>2.1. Stem rot (<i>Atbelia</i>)</p> <p>2.2. Stem canker*</p> <p>2.3. Black flag (<i>Phytophthora</i>)</p> <p>2.4. Fruit rot (<i>Rhizopus</i>)</p> <p>2.5 Fruit rot-(Yeast -many species)*</p>
<p>3. Internal & fruit feeders</p> <p>3.1. Leaf miner*</p> <p>3.2 Beetles(<i>Lasiodactylus</i>)</p>	<p>3. Soilborne diseases</p> <p>3.1. Wilt (<i>Rhizoctonia/Sclerotium?</i>)</p> <p>3.2. Damping off (<i>Phytophthora</i>)</p>
<p>4. Other animal pests</p> <p>4.1. Slugs & snails*</p> <p>4.2 Birds and rodents*</p>	<p>Nematodes</p> <p>4.1. Root knot (<i>Meloidogyne</i>)</p> <p>4.2. Other genera*</p>

@- provisional; confirmation required in several cases; main source: Nelson and Elevitch (2005)

*unidentified/unspecified/many species 4.

Table 2. List of noni crop insect associations observed in Kerala, 2006-2007*

Common name	Scientific Name	Family	Order	Nature of association / Effect on crop
1. Herbivores /crop pests				
Weevil	*	Curculionidae	Coleoptera	Defoliation
Flea beetle	*	Chrysomelidae	Coleoptera	Defoliation
Fruit fly	<i>Bactrocera</i> sp.	Tephritidae	Diptera	Adult stage found on fruits/leaves
Grass hopper	<i>Orthacris</i> sp.	Acrididae	Orthoptera	Defoliation
Plant hopper	*	*	Homoptera	Sap sucking
Red tree Ant	<i>Oecophylla</i> sp.	Formicidae	Hymenoptera	Visiting flowers and leaves
Mite	*	Tetranychidae	Acarina	Flower infesting; sap sucking
2. Pest natural enemies				
Preying mantis	<i>Creoloter</i> sp.	Mantidae	Dictyoptera	Predator on several pest groups
Lady bird beetle	<i>Chilocorus nigrinus</i>	Coccinellidae	Coleoptera	Predator of aphids, whiteflies, moth eggs
Wasp	*	Vespidae	Hymenoptera	Predator of caterpillars
Spider	*	*	Acarina	Predator on tiny insects
3. Pollinators				
Honey Bee	<i>Apis dorsata</i>	Apidae	Hymenoptera	Pollinator

*Not yet determined; based on survey made in the WNRF- funded project

Table 3. List of disease associations on Noni crop observed in Kerala, 2006-2007*

Disease	Pathogen	Symptom
Leaf blight	Fusarium sp.	Typical blight in tip of the leaf and spreading towards the base.
Leaf spot	Colletotricum sp.	Small brown spot in leaf lamina and enlarging in size.
Sooty mold	Unidentified fungus*	Brown mold in the leaf veins. Leaf folding and crinkling commonly observed.
Shot hole	Unidentified*	Many holes in the leaf.
Leaf mosaic	Unidentified virus*	Leaf showing yellowing and mosaic appearances. Leaf is small and growth restricted.
Wilt	Fusarium?/ Rhizoctonia?	Seedlings and plants showing wilting and eventually die. Also associated with root knot nematode.
Root knot	Meloidogyne – nematode	Many knots in the roots and stunted root growth.
Brown fruit rot	Unidentified bacterial/ fungal (association?)*	Fruit progressively brown; symptom on fruit form depression, softening and rotten.
Black fruit rot	Unidentified (bacterial)*	Blackening initiated from petiole and progress towards fruit. Complete blackening of entire fruit.
Uneven ripening	Excess phosphorous?	Uneven fruit maturity and ripening.

*Not yet determined; based on survey made in the WNRF- funded project

Table 4. Potential organic options for use/evaluation in management of insect pests of Noni

Pest group	Type of damage	Plant parts Parts damaged	Damage / symptoms	Promising Organic product	Recommended method of application
1. Caterpillars <i>Spodoptera</i> , <i>Achaea</i> , Horned caterpillars, Hairy caterpillars	Chewing	Leaf	Gaping holes in leaves; veins and petioles remaining	i) Virus -NPV ii) Bacteria -Bt	Apply as spray, add UV protectants
2. Grass Hoppers	Chewing	Leaf	Feeding from edges; large areas damaged	Botanical pesticides	Apply as spray, with surfactants
3. Beetles	Chewing	Leaf	Feeding in the main lamina; small areas damaged	Botanical Pesticides	Apply as spray, with surfactants
4. Fruitflies	Mining	Fruit	Fruits rotting & dropping; with maggots inside	i) Lures for adults ii) Safe disposal of infested fruits iii) Post-harvest disinfestations	i) Kept in traps ii) Placing in pits & covering with net iii) Hot water/ air treatment
5. Leafminer	Mining	Leaf	regular tunnels in leaf with necrosis and premature defoliation	Botanical pesticides	Apply as spray, with surfactants
6. Aphids	Sucking	Leaf/stem/ flowers	Clusters of tiny insects in the main branches/ flower clusters; leaf curling & deformity; sooty mould	i) ii) Entomofungus ii) Predators	i) Apply as spray, with oil base ii) Release Chrysopa adults

Pest group	Type of damage	Plant parts Parts damaged	Damage / symptoms	Promising Organic	Recommended
7. Thrips	Sucking	Leaf	Silvery or bleached look; turns dark brown	i) Botanical pesticides ii) Entomofungus	i) Apply as spray, with surfactants ii) Apply as spray, with oil base
8. Mealy Bugs	Sucking	Leaf/ Fruits	Mealy white sedentary insects feeding on young fruits and flowers; suffer feeding injury.	i) Predatory beetles ii) Entomofungus	i) Release as adults in the crop ii) Apply as spray, with oil base.
9. Green Scales	Sucking	Leaf	Green sedentary insects on shoots/ branches/flower stalks; Stunting, slow growth ;also leaf curling and deformity	i) Botanical pesticides ii) Entomofungus	i) Apply as spray, with surfactants ii) Apply as spray, with oil base
10. Hoppers	Sucking	Leaf	Brown, mobile insects, mainly on underside of leaves; cause cupping & margin browning	i) Botanical pesticides ii) Entomofungus	i) Apply as spray, with surfactants ii) Apply as spray, with oil base
11. Whitefly	Sucking	Leaf	Yellow and wrinkled with conspicuous black sooty mold	i) Botanical pesticides ii) Entomofungus iii) Parasitoids	Apply as spray, with surfactants i) Apply as spray, with oil base iii) Release of <i>Encarsia</i>
12. Eriophyid Mites	Sucking	Leaf	Leaves discolored and shed	i) Botanical pesticides prematurely.	Apply as spray, with surfactants

Table 5 : Potential organic options for use/evaluation in management of diseases of Noni

Disease Group	Cause agent	Plant parts Damaged & Symptom	Promising Organic & eco-friendly Practice	Recommended method of application
1. Noni shot hole	Unidentified fungus	Initially as tiny, maroon coloured specks on leaves and bracts; finally as typical “shot hole” appearance; leaves may drop prematurely	i) Sanitation ii) Use antifungal antagonist	i) Removal and destruction of infected leaves ii) Spray any <i>Pseudomonas fluorescens</i> product
2. Anthracnose leaf spot	<i>Colletotric-hum.</i> (species not determined)	Large expanding leaf spots with dark to tan centres and diffuse, irregular margins	i) Sanitation ii) Use antifungal antagonist	i) Removal and destruction of infected leaves ii) Spray any <i>Pseudomonas fluorescens</i> product
3. Black flag	<i>Phytophthora botryosa</i>	Black leaf spots and leaf blight; brown to black stem blight; brown to black soft rot of fruits; fruit mummification; hanging, diseased leaves referred as “black flags”	i) Sanitation ii) Use antifungal antagonist	i) Removal and destruction of infected leaves. ii) Spray any <i>Pseudomonas fluorescens</i> product
4. Leaf blight	<i>Fusarium</i> sp.	Typical blight appears in tip of the leaf and spread toward the base.	Sanitation	Spray <i>Pseudomonas fluorescens</i> product
5. Sooty mold	<i>Capnodium</i> fungus (due to honey due secretions by aphids, scale insects)	Black, powdery growth, usually on the upper surface of leaves	i) Apply starchy products ii) Control the causal insect	i) Spray with starch powder solution. ii) Spray <i>Metarbizium</i> or <i>Verticillium</i> based product
6. Algal leaf spot (American Samoa)	<i>Cepbaleuros minimus</i>	Brown coloured leaf spot (1-2 cm dia) surrounded by a diffuse, yellow halo	i) Sanitation; ii) Moisture and humidity management	i) Removal and destruction of severely diseased leaves

Disease Group	Cause agent	Plant parts Damaged & Symptom	Promising Organic & eco-friendly Practice	Recommended method of application
7. Stem canker	Associated with an unidentified species of fungus (an ascomycete)	Stem lesions irregular in shape with roughened, dark borders and an overall corky appearance	i) Sanitation in nursery ii) Protective or therapeutic application of organic fungicides	i) Remove & destroy affected seedlings ii) Spray <i>Pseudomonas fluorescens</i> products
8. Stem blight	<i>Sclerotium rolfsii</i> , and root-knot nematodes	Foliar chlorosis and wilting; stem girdling at or near soil line; internal stem necrosis; stem rot; defoliation; plant death.	Avoid the predisposing stresses (flooding, poor drainage, wounding of stems, infection by root knot nematodes)	i) Ensure proper irrigation management ii) Prevent nematode problem, including application of <i>Paecilomyces lilacinus</i>
9. Root knot	Root-knot nematodes (<i>Meloidogyne</i> sp.)	Stubby, swollen, galled roots; leaves turn golden yellow; plants are stunted.	i) Organic manures to reduce the plant growth impact. ii) Nutrient support to plants to tolerate high nematode populations	i) Composts and chicken manure applied around the root zone helps to lower nematode populations ii) Spray with foliar fertilizer products iii) Application of <i>Paecilomyces lilacinus</i>
10. Fruit rot	Unidentified (bacterial/fungal)	Fruit progressively black; softening and rotten.	i) Remove the affected fruits ii) Spray Neem oil	Spray <i>Pseudomonas fluorescens</i> / <i>Bacillus</i> sp. products
11. Wilt	<i>Fusarium?</i> / <i>Rhizoctonia?</i>	Seedling and plant showing wilting and eventually die	Organic amendment with fully decomposed cow dung cake	Soil application of <i>Trichoderma</i> , <i>Pseudomonas</i> and <i>Bacillus</i> based products
12. Mosaic virus	Unidentified virus	Leaf showing yellowing and mosaic appearances. Leaf is small and its growth is restricted.	-	Control vector by spraying Neem oil

Table 6 : Some known plant sources for Pest control Products in India**

Plant Name	Botanical Name	Plant Part Used	Potential Target pests / Diseases	Application Method
Tobacco	<i>Nicotiana tabacum</i> and <i>N. rustica</i>	Leaf	-	Leaf extract and oil as spray
Tulsi	<i>Ocimum sanctum</i>	Leaf	Leaf miners and leaf curl disease	Leaf extract spray
Marigold	<i>Tagetes</i> sp.	Leaves and roots	Leaf/root diseases. Attracts bollworm eggs. Controls nematodes.	Use crushed leaf/ root extract as spray
Mahua	<i>Madhuca longifolia</i>	Seed/Leaf	Stem/root rots.	Oil emulsion in water or aqueous leaf extract as spray
Methi	<i>Trigonella foenumgraecum</i>	Leaf	Several insect pests	Crushed and boiled leaf extract used as spray
Sitaphal / Custard apple	<i>Annona squamosa</i>	Seed/Leaf	Several pests including diamond-back moth and pod-borer	Seed/leaf extract used as foliar spray
Datura	<i>Datura metel</i>	Leaf	Stored grain pests. Fungal diseases like. brown rust	Powdered dry leaf as dust, leaf extract as spray
Castor	<i>Ricinus communis</i>	Seed	Weevils, aphids and caterpillars	Mix oil with water as emulsion and spray
Ipomoea	<i>Ipomoea raptons</i>	leaf	Sucking pests like bugs/white-fly, fungal diseases like sheath rot, brown rust.	Dry leaf ground as dust. Fresh leaf extract as spray

Plant Name	Botanical Name	Plant Part Used	Potential Target pests / Diseases	Application Method
Chrysanthemum	<i>Chrysanthemum cinerariifolium</i>	Flower	Aphids, white-flies, spider mites, mealy bugs, termites	Make boiled extract and apply as spray.
Mauri	<i>Foeniculum Vulgare</i>	Leaf	Several insect pests.	Boil dried leaves. Filter and use as spray.
Bael Patra	<i>Aegle marmelos</i>	Leaf/fruit	Several chewing and sucking insects	Crush fresh leaves and fruits, boil with water.
Amaranth	<i>Amaranthus blitum</i> & <i>A. tricolor</i>	Leaf	Brown rust	Crush leaves, boiled in water.
Lantana	<i>Lantana camara</i>	Leaf	Leaf miner	Fresh leaves crushed and used as spray
Turmeric	<i>Curcuma longa</i>	Rhizome	Root rots and as seed dresser	Dried rhizome powdered and used as dust
Garlic	<i>Allium sativum</i>	Bulb	Beetles, caterpillars, aphids, thrips; also bacterial and fungal diseases	Crushed extract as spray
Neem	<i>Azadirachta indica</i>	Kernel/seed	Wide range of insect pests; also nematodes	Crushed kernel extract, filtered and sprayed
Pungam	<i>Pongamia glabra</i>	Seed/fruit	Wide range of insect pests. Also nematodes	Oil extract used as emulsion spray
Aloe vera	<i>Aloe vera</i>	leaf	Caterpillars, aphids, bacterial/fungal diseases	Crushed leaf extract used as spray

**Source: Krishan Chandra et al. (2005)

Cues for ISR and Trophic Interactions of PGPR and their Possible Applications for the Management of Pests and Diseases of Noni (*Morinda citrifolia*. L)

T. Marimuthu* and S. Nakkeeran*

Abstract

The Indian Noni (Morinda citrifolia L.), a well known medicinal plant, succumbs to several diseases, insect pests and nematodes. Eco-friendly approaches to manage these biotic stresses would pay dividend in the International market.

Plant Growth Promoting Rhizobacteria (PGPR) plays a vital role in crop protection, growth promotion and in the improvement of soil health. PGPR (Pseudomonas, Bacillus, Azospirillum, Rhizobium, and Serratia spp.) produces antibiotics pertaining to polyketides, heterocyclic nitrogenous compounds and lipopeptides, which are regulated by a cascade of endogenous signals such as sensor kinases, N-acyl homoserine lactones and sigma factors. The antibiotics of PGPR origin are broad-spectrum in action which are effective against several plant pathogens.

In addition to direct antifungal action, they also serve as determinants in triggering induced systemic resistance (ISR) in the plant system via activating various molecular signals such as salicylic acid, jasmonic acid and ethylene, which are the major players in the regulation of signaling network. It leads to positive cross talk and triggers pathways such as phenyl propanoid, octadecanoid and isoprenoid pathway in the host plant and releases higher amounts of defense compounds that protect the plant from pests and diseases including nematodes.

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As an indirect means, jasmonic acid induced by PGPR triggers volatile production and attracts natural enemies of herbivores besides triggering interplant communication enhancing the immunity in neighbouring plants. The paper discusses ways and means to utilize PGPR consortia bestowed with antibiosis coupled with simultaneous triggering of ISR for the possible management of pests and diseases of Noni.

Introduction

Noni (*Morinda citrifolia*), a well known plant exploited for its pharmaceutical and nutraceutical properties is reported to succumb to several fungal and nematode diseases and insect and non-insect pests that are likely to cause economical loss to the cultivator when it is intensively cultivated on commercial basis. Noni being a medicinal plant, pest management strategies need to be re oriented from the routine conventional methods of using chemical pesticides to the non-chemical methods integrating all the good agricultural practices (GAP) employed for crop production including the use of beneficial microbes and the like. In short, the knowledge of the crop ecosystem and their interaction with key inputs like water, nutrients and the rhizosphere and phyllosphere microbes besides the biotic and abiotic stresses that always put the plant under stress to defensively respond or succumb to the stresses depending on the ecological conditions that determines the priority of response of the plants to stresses need to be understood so as to derive maximum benefits out of a given strategy. A sustainable approach to manage 'pests' by combining biological, cultural, physical and chemical tools is a way that minimizes economic, health and environmental risks should be the priority of pest management in Noni or as a matter of fact with any other crop production system. Besides, some of the information available in the literature that focus on the fundamentals of trophic interactions of the host plants with cross talk or trade offs so that such cues could be beneficially exploited to reorient our approach to Noni crop protection techniques. It is also becoming important in the context of globalization the commodities we produce from Noni meet the global standards in terms of quality; one of the important quality parameter being freedom from pesticide residues.

2. Pests and disease scenario of Noni :

Several fungal, nematode, insect and non-insect pests are reported from Hawaii where Noni is being cultivated on commercial basis (Nelson, 2003) (Table-1).

Table 1: Pests and diseases of Noni

I. Diseases	
i. Black Flag (<i>Phytophthora botryose</i>)	<p>Symptoms :</p> <p>Blackened, withered, or completely necrotic leaves hanging from blackened petioles and stems. In the early stages of infection the leaves, petioles, and stems may have blackened streaks or stripes along the veins.</p> <p>Fruit symptoms: progressive soft rot with a water-soaked appearance with chocolate-brown or dark brown to black color. Advanced fruit infections may result in dry, shriveled fruits that may have a fuzzy or silvery surface.</p> <p>All non-woody Noni organs and tissues (e.g., leaves, flowers, fruit, petioles, succulent stems, and stipules) are susceptible especially during rainy periods. Dead leaves and stems may hang from trees for weeks until the dead foliage decomposes and new stem and leaves are formed.</p>
ii. Stem rot (<i>Sclerotium rolfsii</i>)	<p>Symptoms :</p> <p>Foliar chlorosis and wilting; stem girdling at or near soil line; internal stem necrosis; stem rot; defoliation; plant death; white fluffy fungal mycelium and brown sclerotia could be seen at soil line.</p>
iii. Anthracnose (<i>Colletotrichum</i> sp.)	<p>Symptoms :</p> <p>Large expanding leaf spots with dark to tan centers and diffuse, irregular margins leading to . “target spots” Lesions may coalesce to form large, blighted areas on leaves, often at leaf margins.</p>

<p>iv. Stem canker (Unknown cause) Symptoms : Progressive rot of stem at the interface between woody and green stem tissues. Stem may be girdled leading to plant death. Stem shows overall corky appearance.</p>
<p>v. Plant parasitic algae (<i>Cephaleuros minimus</i>. <i>Cephaleuros</i> spp) Symptoms : Leaf spots characterized by a light brown color, surrounded by a conspicuous, diffuse, yellow halos. Sporangia and setae break through the lower epidermis and can usually be seen as bright orange coloured raised spots.</p>
<p>vi. Sooty mold (Ubiquitous air borne fungi) Symptoms : Black, powdery growth usually seen on the upper surface of leaves. The black growth is not pathogenic (it does not penetrate leaf tissues) and exists as a thin layer that can be scraped off easily. Sooty molds are due to the honey dew or sugary secretion of the feeding sucking pests like aphids, scales and jassids.</p>
<p>vii. Post harvest fruit rot (<i>Rhizopus</i> spp) Symptoms: Cottony, fluffy growth of the fungus could be seen on fruits leading to rotting.</p>
<p>II. Nematodes</p>
<p>i. Root knot (<i>Meloidogyne</i> spp.) Symptoms : Leaves become yellow; plants are stunted; roots are galled, distorted, cracked and rotten</p>
<p>III. Pests</p>
<p>i. Mealy bugs Symptoms : Young fruits and flowers are susceptible to feeding injury and the insects could be seen as white fluffy growth.</p>

ii. Green scale (<i>Coccus viridis</i>)
Symptoms : Scales feed along primary veins on the underside of leaves; stunting and slow growth of noni plants; leaf curling and deformity; scale infestation may invite sooty mold.
iii. Green house Thrips (<i>Heliothrips haemorrhoidalis</i>)
Symptoms : Injured tissues show silvery or bleached appearance and eventually turns to dark brown. Premature defoliation may occur.
iv. Leaf miner (Unidentified)
Symptoms : Feeding results in pale green colored, irregular tunnels within the leaf tissue.
v. Spiralling White fly (<i>Aleurodicus dispersus</i>)
Symptoms : Leaf discoloration (dulling, browning, yellowing, necrosis); leaf distortion (curling, crinkling, stunting); slow plant growth; premature defoliation. The Kirkaldy whitefly, <i>Dialuerodes kirkaldyi</i> is also reported to occur causing similar damage.
vi. Aphids (<i>Aphis gossypii</i>)
Symptoms : Leaf curling and deformity of leaves; invites sooty mold due to sugar secretion by aphids.
IV. Non-insect pests
i. Eriophyid mite (unidentified)
Symptoms : Feeding causes leaves to curl and wrinkle leading to a bronze scorching and necrosis of leaf margins.

ii. African snails

Symptoms / sign :

Can see the presence of the snails feeding the foliage.

3. Plant Disease Management *per se*

Plant disease management has been one of the major components of any crop production systems and this could be achieved only when thorough knowledge about the diagnosis, its causative agent(s), mechanism of disease development and spread, economic and social implications become available. The plant or the crop as such has to face the onslaught of diverse biotic and abiotic stresses. Plants try to interact with them under the influence of the overall weather factors and respond accordingly. The response is mostly defensive and the success depends largely on the nature of compatibility between the host and the pathogen or the biotic agent(s). As we understand more and more about the interaction of the host and the agents it will be all the more easy to devise appropriate tool or technology to manage any disease or biotic agent(s). Development of Plant Protection technology and delivery need to be in a continuum and should be interactive. If we trace the development of technology over the past decades, the development was continuous and many a times it was not interactive with the other components of production technology. Commodity based production is giving way to system based production and there is a paradigm shift using farming system to production to consortium system of operation. Diversification of production is fast happening along with widespread dietary evolution. The major recommendations of the National Commission on Farmers in its third report are soil health, technology and inputs, which have bearing on plant protection. Under optimized soil health the Biocontrol Agents (BCA) or the beneficial microorganism can do their job more efficiently. In the fast changing scenario of crop production owing to compulsion due to the globalization and environmental concerns, an ecologically sustainable method for the management of pests and diseases is highly desirable.

4. Role of Rhizosphere microbes in plant health

The soil microorganisms, which are capable of exerting beneficial effects has potential for use in both agricultural, horticultural and medicinal crops which result in enhanced yield.

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The type of system and their mode of action are nitrogen fixation, phosphate solubilization and mobilization, production of plant growth regulators, siderophores, lytic enzymes and antibiotics and Induced systemic resistance. Plant pathologists have been highly successful using antagonists against some harmful plant pathogens. One of the success stories in several countries involve the use of *Agrobacterium radiobacter* strain K84 to prevent crown gall, a plant tumor caused by a related organism, *A. tumefaciens*. Biological control using naturally occurring organisms to maintain the pathogen population at a level that does not require further control measures is one of the most advantageous options in disease management. One can be very optimistic that future disease management programs would increasingly incorporate this novel method. Biological control methods are probably the ideal input for IPM, which combines different control tactics.

Biological control aims to conserve existing populations of naturally occurring organisms by adopting production practices that favor populations of these beneficial microbes. Examples of such practices can include the use of less toxic pesticides and / or the timing of agricultural practices to minimize their disruption on beneficial species. However, little is known about the conservation of beneficial microbes in the sustainable agriculture and it is possible to maximize our ability to tailor agricultural practices to optimize crop productivity while positively affecting beneficial soil organisms and the functions they perform. The exploitation of beneficial microorganisms as biopesticides for the control of various plant pathogens has attracted considerable interest (Cook and Baker, 1983). Fungal BCA, *Trichoderma viride*, *T. barzianum*, *Gliocladium virens* and bacteria, including *Pseudomonas fluorescens* Migula, *Bacillus subtilis* (Ehrenberg) Cohn, *B. brevis* Migula, *B. cereus* Frankland and Frankland, *B. megaterium* de Bary, *P. aeruginosa* (Schroeter) Migula, and *P. putida* (Trevisan) Migula have been studied as biocontrol agents for managing plant pathogens in many crop production system. Several species of BCA are being commercially exploited all over the world (Vidhyasekaran and Muthamilan, 1995; Vidhyasekaran *et al.*, 1997).

4.1. Plant Growth Promoting Rhizobacteria (PGPR)

PGPR are a group of free-living microorganisms that favourably affect plant growth and yield of important crops and are the subset of rhizosphere bacteria known to aggressively colonize roots (Schroth and Hancock, 1982). Since the rhizosphere microflora is extremely diverse,

a dynamic interplay between the members of the microbial community occurs, mediated by synergistic and antagonistic interactions (Garbeva *et al.*, 2004). In addition signals are exchanged between fungi and bacteria and plant roots, effectively forming a highly dynamic below ground communication network (Somers *et al.*, 2004). The microbial-plant network is maintained for the life time of the root and exerts a buffering action on the rhizosphere environment (Van Loon and Bakker, 2005). They may directly contribute to the increased plant growth by N₂ fixation (Hong *et al.*, 1991), solubilizing nutrients such as P (Whitelaw, 2000), promoting mycorrhizal function (Garbaye, 1994), regulating ethylene production in roots (Glick, 1995), releasing phytohormones (Beyeler *et al.*, 1999) and decreasing heavy metal toxicity (Burd *et al.*, 1998). The PGPR may also indirectly contribute to the growth of plants by suppression of pathogens. Besides they may behave as an endophyte as they are able to grow and complete their life cycle on the root surface, capable of developing within the root thus protected from adverse environment and competitors. Benhamou *et al.* (1996) reported that in the pre-bacterized roots restriction of pathogen growth to the epidermis, strengthening of cell walls, deposition of newly formed barriers and accumulation of phenolic compounds in intercellular spaces to take place. These bacteria belong to the genera *Azotobacter*, *Azospirillum*, *Arthrobacter*, *Bacillus*, *Burkholderia*, *Enterobacter*, *Klebsiella*, *Pseudomonas*, *Xanthomonas*, and *Serratia*. Several other PGPR help to enhance plant growth by indirect mechanisms, such as suppression of bacterial, fungal and nematode pathogens (biocontrol) by production of various metabolites, induced systemic resistance and/or by competing with the pathogen for nutrients or for colonization of space.

4.2. PGPR and Induced resistance

Induced resistance is defined as an enhancement of the plant's defensive capacity against a broad spectrum of pathogens and pests that is acquired after appropriate stimulation. The resulting elevated resistance due to an inducing agent upon infection by a pathogen is called induced systemic resistance (ISR) or systemic acquired resistance (SAR) (Hammerschmidt and Kuc, 1995). The induction of systemic resistance by rhizobacteria (RB) is referred as ISR, whereas that by other agencies is called SAR. SAR is expressed to a maximum level when the inducing organism causes necrosis whereas ISR by PGPR typically do not cause any necrotic symptoms on the host plants (Van Loon *et al.*, 1998). Both SAR and ISR are the activation of latent resistant mechanisms that are expressed upon subsequent or challenge

inoculation with a pathogen. The broad spectrum of control using PGPR strains can provide an effective, economical and practical way of plant protection

ISR has emerged as potential tool to manage root and foliar diseases. PGPR are also having the ability to protect above ground plant parts against viral, fungal and bacterial diseases by induced systemic resistance (ISR) (Kloepper *et al.*, 1992). Among the PGPR, fluorescent pseudomonads are the most exploited bacteria for biological control of soil borne and foliar plant pathogens as they promote the growth and development of crop plants besides disease control. In the past three decades numerous strains of fluorescent pseudomonads have been isolated from the soil and plant roots by several workers (Ramamoorthy *et al.*, 2001). The non specific character of induced resistance constitutes an increase in the level of basal resistance to several pathogens simultaneously, which is of benefit under natural conditions where multiple pathogens may be present. Specific *Pseudomonas* strains induce systemic resistance in carnation, cucumber, radish, tobacco and *Arabidopsis*, as evidenced by an enhanced defensive capacity upon challenge inoculation. Although some bacteria strains are equally effective in inducing resistance in different plant species, others show specificity, indicating specific recognition between bacteria and plants at the root surface.

Specific PGPR strains bring about induced resistance against multiple pathogens attacking the same crop. In addition to disease suppression, application of PGPR also reduces the insect and nematode damage. The endophytic nature of some PGPR make them suitable for the use in vegetatively propagated crops because of their capacity to colonize and persist in the intercellular space of epidermal cells thereby reducing the need for further application if the same vegetative parts are used for propagation. Furthermore, certain PGPR strain mixtures have showed synergistic action in plant protection and growth promotion, indicating involvement of different mechanisms in disease control.

In recent years, the use of PGPR as an inducer of systemic resistance in crop plants against different pathogens has been demonstrated under field conditions (Nandakumar *et al.*, 2001; Radjacomare *et al.*, 2002). The utilization of natural PGPR strains as inducers of plant defense responses may increase the chance of their applicability and offers a practical way to manage plant diseases.

4.3. Mechanism of induction of Induced Systemic Resistance (ISR)

For defense plants are endowed with pre-existing physical barriers that limit damage, such as cuticle and hardened woody covers that may successfully withstand the aggression of small herbivores or pathogens. Plants have evolved towards the capacity of making each cell competent for the activation of defence responses which largely depend on the transcriptional activation of specific genes.

The protective effect due to RB should have been plant mediated as the RB and pathogenic fungi were never found to contact each other on the plant. The inducing RB triggered a reaction in the plant roots resulting in a signal that spread systemically throughout the plant and enhanced the defensive capacity of distant tissues to subsequent infection by the pathogens. ISR can reduce damage from the pathogens that are active exclusively on foliage, flowers or fruits (Hoffland *et al.*, 1996).

4.3.1. Induction of ISR

Beneficial RB does not damage their host or cause localized necrosis. Therefore the eliciting factor(s) produced by ISR-triggering RB must be different from elicitors of pathogens. The induction shows some similarities to the generation of non-specific defense reaction in plant cells that occur in response to general pathogen associated molecular patterns (Gomez-Gomez, 2004; Nurnberger *et al.*, 2004). The induction of ISR may depend on the type of strain and the plant species that interact. The determinants of ISR may be the production of siderophores, antibiotics, lipopolysaccharides, volatile compounds and the population densities of the inducing RB (Tables -2, 3).

Table 2: Differential induction of Induced Systemic Resistance by *Pseudomonas* species

Plant Species	<i>P. putida</i> WCS358	<i>P. fluorescens</i> WCS374	<i>P. fluorescens</i> WCS417
<i>Arabidopsis</i>	Induction	No induction	Induction
Bean	Induction	Not determined	Induction
Tomato	Induction	Not determined	Induction

Source: Siddiqui, 2005

Noni Search 2007 - Proceedings of Second National Symposium on Noni for Health and Wellness, Chennai.

Table 3: Determinants of Induced Systemic Resistance in plant species

Bacterial strain	Plant species	Determinant
<i>P. aeruginosa</i> 7NSK2	Bean	Salicylic acid (SA)
<i>P. fluorescens</i> CHAO	Tobacco	Siderophore
	Tomato	2,4-Diacetylphloroglucinol
<i>P. fluorescens</i> WCS 417	Carnation	Lipopolysaccharide
<i>P. putida</i> WCS358	<i>Arabidopsis</i>	Flagella
	Bean	Lipopolysaccharide, Siderophore
	Tomato	Lipopolysaccharide, Siderophore

Source: Siddiqui, 2005

4.3.2. Signaling in Rhizobacteria (RB) induced systemic resistance

ISR of plants against pathogens is a widespread phenomenon that has been intensively investigated with respect to the underlying signaling pathways as well as to its potential use in plant protection. Elicited by a local infection, plants respond with salicylic-dependent signaling cascade that leads to the systemic expression of a broad spectrum and long-lasting disease resistance that is efficient against fungi, bacteria and viruses. Changes in cell wall composition, *de novo* production of pathogenesis related proteins (PRs) such as chitinases and glucanases and synthesis of phytoalexins are associated with resistance (Heil and Bostock, 2002). Systemically induced resistance, whether SA-dependent SAR or JA and ethylene-dependent ISR, both are involved through enhanced activation of defense responses upon challenge inoculation. SAR is associated with the accumulation of PRs and negatively affects plant growth (Heil, 2002), most of the ISR triggering RB have been selected primarily because of their plant growth promotion. These properties make ISR-inducing RB as a useful tool to reduce diseases caused by pathogens that are sensitive to JA and ethylene dependent defenses. Stimulation of plant growth will lead to increased plant vigor and a shorter period vulnerability before adult plant resistance may have become sufficient to limit damage by the pathogen.

ISR-eliciting RB can be applied on seeds and then will readily colonize emerging plant roots. Thus, seedlings can be better protected already at an early stage (Leeman et al., 1995). These properties make ISR-inducing PGPR as useful tool to reduce diseases caused by pathogens that are sensitive to JA- and ethylene dependent defenses. Combination of ISR and SAR can increase protection against pathogens that are resisted through both the mechanisms, as well extend protection to a broader group of pathogens than ISR or SAR alone. ISR is one of the mechanisms that may be integrated in to disease management program since this approach is eco-friendly and durable.

Signaling in ISR appears considerably more complex. Some RB are capable of producing SA *in vitro* on minimal media in the absence of iron (Van Loon *et al.*, 1998). Such bacteria, when encountered in the rhizosphere, are expected to induce SAR. The SA produced by the bacterium may be incorporated in to SA-containing siderophore, rather than secreting in to the rhizosphere. If the siderophore is a inducing determinant bacterium may trigger SAR pathway or a different pathway. Several ISR eliciting strains have been described to be capable of producing SA. Whether ISR is triggered through SA-dependent SAR pathway is to be understood.

Two *Bacillus* species were found to induce ISR through the volatile compound, 2,3 butanediol and it was found to be independent of SA and dependent on ethylene and apparently did not require JA (Ryu *et al.*, 2004). In general ISR is not dependent on SA but ISR has a variable requirement for JA and ethylene signaling (Van Loon and Bakker, 2005).

4.3.3. Sensitivity to JA or ethylene

ISR signaling appears to require responsiveness to JA rather than increased levels of JA. Similarly sensitivity to ethylene is required for ISR as ethylene insensitive *Arabidopsis* mutants *etr1* and *ein 2* were unable to express ISR up on elicitation with *P. fluorescens* WCS 417 (Pieterse *et al.*, 1998). Knoester *at al.* (1999) found that all ethylene insensitive mutants were unable to express ISR.

5. Cross talk and trade offs- boon or burden?.

Cross talk can be simply defined as induced resistance against a pathogen induced by a herbivore or *vice versa*. Resistance elicited by one group of enemies is active against another group (Heil and Bostock, 2002) (Table-4). Inhibition of one resistance pathway by another is known as trade off (Table-5).

Table 4: The cases reported as Cross talk

Crop	Insect	Pathogens
Watermelon	Feeding by thrips and aphids	Reduces <i>Colletotrichum orbiculare</i>
Soybean	Soybean looper	Reduces stem cander (<i>Diaprthe phaseolorum</i>) Crown rot (<i>Cylindrocladium crotalariae</i>)
Tomato	<i>Helicoverpa zea</i>	<i>Pseudomonas syringae</i>

Table 5: The cases reported as Trade offs

Crop	Treatment for suppression of diseases	Suppression
Tomato	Chemical induction	Suppress Protein Inhibitors
Tomato	Acibenzolar (BION)	Susceptible to herbivores
Tomato	SA	Inhibits JA
Tomato	Acetyl SA	Inhibits Protein Inhibitors synthesis

Salicylic acid accumulates after pathogen infection resulting in the activation of NPR1 (Non-expressive pathogenesis related protein 1). Activated NPR1 is then localized into the nucleus,

where it interacts with TGA transcription factors leading to the activation of SA responsive PR genes. In cytosol, NPR1 negatively regulates jasmonic acid responsive gene expression. The suppression of JA responsive genes that encoded enzymes from the octadecanoid pathways, such as *LOX2* (lipoxygenase-2), PDF1.2 (plant defensin) etc, results in the inhibition of JA formation (Siddiqui, 2005). The hypothetical model illustrated in Fig.1 will through more light on cross talk or trade off.

Fig 1: Defensive pathways stimulated due to biotic stressed and PGPR applications

Strong efforts are required to identify the compounds causing resistance and future studies should quantify these compounds in combination with biologically detectable resistance to characterize the induced stage. Experiments thoroughly exploring signaling conflicts and synergies in plant-herbivore and plant pathogen interaction will be essential to realize fully the potential of inducible resistance strategies in pest management (Heil and Bostock, 2002)

5.1. PGPR showing cross resistance – some case studies

Application of PGPR either through seeds or in soils for the management of diseases in several crop plants showed considerable reduction in pests of the same crop as shown in the tables (Table-6)

Table 6 : PGPR application resulting in cross resistance to insect pests

PGPR	Mode of delivery	Crop	Pests controlled
<i>P. galdeoli</i>	Seed treatment	Cotton	<i>Helicoverpa</i>
<i>P. putida</i> <i>B. pumilis</i>	Seed treatment	Cucumber	Striped & spotted Cucumber beetles
<i>Azosprillum</i>	Seed treatment, Soil application	Sorghum	Shoot fly
<i>B. subtilis</i> <i>B. pumilis</i>	Seed treatment, Soil application	Tomato	White fly

The field /green house studies conducted at Tamil Nadu Agricultural University, Coimbatore using fluorescent pseudomonads with several crops showed that application of PGPR either through seeds / soil / foliar or combinations could effectively check the pathogens, some insect pests and nematodes. Seed treatment with PGPR bacterium and *Trichoderma viride* resulted in reduction of *Heterodera cajani*, the cyst nematode in pigeon peas by 33 per cent besides 22 per cent increased grain yield. (Table-7)

Table 7: Effect of PGPR (*P. fluorescens*-Pf1), when treated with Pigeon pea seeds

Treatments	Nematode population (eggs,juveniles/g soil)	Grain yield (Kg/ha)
<i>P. fluorescens</i> + <i>Trichoderma viride</i> @ 5g/kg each	17.38 (-32.50)	776.98
Untreated control	25.75	635.71
CD (p=0.05)	3.59	

Soil application of PGPR viz., Pfbv + Bbv 57 significantly increased the growth parameters in betel vine and reduced the *M. incognita* population and the *Phytophthora* wilt disease ((Jonathan *et al.*, 2006). The leaf yield was significantly higher than the chemical treated plots (Table-8).

Table 8 : Effect of PGPR application on betel vine leaf yield and nematode and wilt incidence

Treatment	1 month after application			2 month after application		
	Nematode population (J2/ 250 ml soil)	Wilt incidence (%)	Leaf Yield (nos.)	Nematode population (J2/ 250 ml soil)	Wilt incidence (%)	Leaf Yield (nos.)
Pf1 + Bbv 57	140.5	26.3 (30.87)	466.6	170.9	29.3 (32.78)	546.4
Metalaxyl (0.2%) + Carbofuran (2g/vine)	121.9	7.03 (15.37)	440.0	139.9	10.51 (18.92)	445.2
Untreated control	326.3	34.53	286.6 (35.99)	405.5	37.72 (37.89)	284.4

In another study with the native strains of *P. fluorescens*, application of PfB22 to banana under green house condition showed considerable reduction (59 %) in *M. incognita* infestation in banana as compared to carbofuran application (48 % reduction) (Jonathan *et al.*, 2006a).

6. Approaches suggested to develop Biopesticides / PGPR suitable for Noni ecosystem

Notably the cost of the chemical protection is often cheaper than biological products which have limited shelf life. However, ISR is one of the several mechanisms that may be mobilized to counteract plant pathogens is an environmentally friendly and durable way. Integrating ISR-triggering PGPR into disease management programs in conjunction with other strategies will be a worthy approach to explore. We may have strongly address the following issues to achieve sustainable strategies using PGPR or any beneficial microbe to manage pests and diseases.

Issues :

- Looking for the native rhizosphere, phyllosphere / phylloplane organisms having antagonistic potentials as well the growth promoting ability
- PGPR that can induce cross resistance to herbivores and nematodes in a reasonably good way
- Improving or modifying the screening strategies to select effective biocontrol agents / PGPR
- Knowledge on the ecology of biocontrol strains employed and the plant pathogens
- Crop and Stage specific isolates
- Optimization of carriers and stickers for formulation development with longer shelf life with mass production technology
- Developing microbial consortia on need basis
- Cost reduction in production and delivery at the field level
- Knowledge and skill on the production and delivery of BCA
- Basic studies to understand the mechanism behind the cross resistance to multiple pests and diseases including nematodes.

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Bionomics and population dynamics of *Dulinius conchatus* Distant (Tingidae : Heteroptera), a pest of *Morinda tinctoria**

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Abstract

The bio-ecology of Dulinius conchatus Distant (Tingidae : Heteroptera), a pest of Morinda tinctoria, was investigated with special reference to its nymphal taxonomy, morphometric and allometric growth patterns, feeding, mating and ovipositional behaviours, and population dynamics. The nymphal stages have been described and illustrated. The morphometric and allometric growth patterns with reference to postembryonic developmental stages and adult exhibited a linear growth pattern in all the nymphal instars. The life cycle from egg to adult of D. conchatus was 20.2 days. The adult longevity in female was 23.2 days as against 20.2 days in male. The fecundity on an average was 150.7 eggs.

Key words: Bio-ecology, *Dulinius conchatus*, Tingidae, *Morinda tinctoria*,

Introduction

The lace bugs, small to medium sized phytophagous bugs, infest mainly leaves and shoots of plants by sucking the sap and cause yellowish or white spots. In case of severe attack, leaves become brown, shrivel and dry up. In India, many species are considered as economically important viz., *Stephanitis typicus* on banana, coconut, cardamom, turmeric, etc., (Mathen *et al.*, 1972 & 1983; Patil *et al.*, 1988), *Urentius* spp. on brinjal (Bhandari and Sohi,

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1962); *Galeatus scrophicus* Saund. on sunflower and niger (Verma *et al.*, 1974; Rao and Thirumalachar, 1977); *Corythauma ayyari* Drake on *Jasminum* spp. (David, 1958; Dorge, 1971; Nair and Nair, 1974); *Cadmilos retiarius* on *Helianthus annuus* (Livingstone, 1962); *Habrochila laeta* Drake on *Barleria cristata* (Mohanasundaram and Basheer, 1963; David and Rangarajan, 1966; Asari, 1972); *Cystechila ablusa* Drake on *Baubinia* spp. (Sandhu and Sohi, 1979); and *Monosterira* spp. on *Zizyphus jujuba* (Mohanasundaram, 1973; Bhalla and Mann, 1988).

Except for a report of its occurrence on *Morinda tinctoria* in a severe form by Mohanasundaram (1962) information on the biology of *Dulinius conchatus* is lacking. The present study was aimed at investigating the biology, description and illustration of nymphal stages, behavioural aspects and population dynamics of the bug.

Materials and Methods

Regular field survey and collection of nymphs and adults of *D. conchatus* Distant was made from *Morinda tinctoria*. This insect was reared on small branches of its host plant enclosed with large nylon bags (40 x 25 cm) for field observations. Laboratory colonies of nymphs and adults of lace bugs were reared in glass chimneys (7.5 x 25 cm) at temperature of 27 to 30°C and relative humidity of 70 to 80%. The broad end of each chimney was covered with a piece of muslin cloth. Through the narrow end of chimney a fresh twig of the host plant was inserted through a split thermocole piece plugging the narrow end. The cut end of host plant was immersed in knop's solution. The scanning micrographs were made using a Hitachi Scanning Electron microscope model (S415A) under 10 KV emission current.

Preservation, mounting and description : The I to V nymphal as well as adults (male and female) of *D. conchatus* were separated from stock culture a day after moulting. They were dehydrated in 70% absolute alcohol for 2-3 days. The dehydrated materials were treated in 10 per cent KOH for 10 to 12 h for clearing the tissues, transferred to glacial acetic acid to dissolve the organic matter, if any, and stained in 1 per cent acid fuchsin. The stained material was passed in acetic acid and carbol xylol to remove the excess stain. The material was then immersed in clove oil and excess clove oil removed by xylol. The specimens were mounted on the slides in DPX mounting medium. Stereoscopic binocular compound

microscope Carl ZEISS LABOVAL 4 was used to study the morphological characters. The figures were drawn using camera lucida with desired magnification.

Morphometric and Allometric growth patterns: Measurements of eggs, nymphs, adults and their body parts were made by using an ocular micrometer. Total body length of each instar was measured from the tip of the stylus to the tip of the abdomen and measurements were also taken of the various body parts such as length and width of head, rostrum length, length of antennae, length and width of head, length and width of prothorax, length and width of abdomen and components of hind legs. All the measurements were plotted against their respective total body length in “log-log” graphs. The allometric growth was studied by using Huxley’s (1924) formula.

$$Y = bX^K$$

Where Y = Allometrically growing segments

b = the initial growth index of the values of Y when X equals unity.

K = the growth ratio, and

X = the body length taken as the referred measured measurements and the growth ratios and initial coefficients for the various parts and calculated.

Results and Discussion

1. Description of different stages: A detailed description of the egg, the five nymphal instars and the adult male and female are rendered here. (Vide Figs. 1 and 2; Plate 1 & Tables 1 and 2)

Egg : Smooth, without sculpturing, white throughout, 0.47 mm long, 0.18 mm wide; flask shaped with the neck bent to one side; anterior end obliquely truncate and provided with an oval lid. The lid with submarginal ridge enclosing an oval impressed area.

Nymphal stages

First Instar: 0.49 mm long; 0.26 mm wide, elongate and sub-cylindrical. Almost colourless when hatched, but soon turning to pale yellow, abdomen with green hue. **Head :** 0.11 mm long ; 0.15 mm wide (across eyes). Head rounded in front, narrowed behind the eyes,

armed with five strong tubercles, two above the base of beak, one just behind anterior pair bearing two club shaped setae at apex and two tubercles near the posterior margin. Eyes lateral, not prominent, consisting of five distinct red ommatidia. Antenna 0.26 mm long; 4 segmented, first two segments short and stout, subequal in length, segment IV bearing numerous setae apically. Rostrum 4 segmented, 0.6x as long as body and inclined backwards. **Thorax** : Slightly wider than head at its widest part. Prothorax little larger than mesothorax and metathorax. Pro and mesothoracic segments bearing a long slender tubercle on each lateral margin, in addition a pair of mid-dorsal tubercles. Legs quite stout and when straightened nearly as long as body, sparsely setose; coxa stout and broad; trochanter difficult to distinguish; tibia little longer than the femur, more slender bearing several short slender spines at apex, tarsus two segmented, the basal segment being smaller; triangular in outline in section from the side; last tarsal segment rounded above, flat below bearing two stout claws. Tarsus little more than 0.5x as long as tibia. **Abdomen**: Ten segmented, nine quite long and bends downwards. Tenth segments reniform viewed from sides, segments II – IX bearing long slender tubercles on margins. Abdominal segments V, VI & VIII bearing unpaired tubercle mid-dorsally. Tubercle on segment II smaller than the rest.

Second instar: 0.65 mm long ; 0.32 mm wide; light yellowish. **Head**: 0.15 mm long ; 0.19 mm wide. Possessing five short, stout tubercles; a pair of frontal processes reaching with their apices to about half of clypeus, with two large club to trumpet shaped glandular hairs growing out of them; an unpaired median frontal tubercle moderately bilobed (with two lobes on its apex) with a short club shaped setae emerging from each lobe; a pair occipital processes surpassing the level of the posterior margins of the eyes, with three to five setae growing out of them. Eyes not prominent, consisting of 6-7 red ommatidia. Antenna 4 segmented, 0.35 mm long; segments I and II subequal, segment III little longer and segment IV longest. Rostrum reaching caudal margin of abdominal segment II. **Thorax and abdomen**: Pronotum 0.17 mm long ; 0.29 mm wide; and mesothorax and abdominal segments IV – IX bearing lateral tubercles; unpaired dorso-median tubercles on mesonotum and abdominal segments V, VI and VIII.

Third instar: 0.89 mm long ; 0.43 mm wide. Body elongate, yellowish with white medial and lateral margins. **Head** : 0.18 mm long ; 0.27 mm wide. All the cephalic tubercles stouter and longer than third instar. Eyes prominent with more than ten compact ommatidia.

Antenna 0.50 mm long. **Thorax** : Pro- and mesothorax proportionally broader than before prothorax longer; wing rudiments appearing as flat conical projection from posterior-lateral margins of pterothorax; five tiny tubercles arising from the dorsal surface of prothorax; one pair of horn like tubercles arise from about first quarter of the mid-dorsal line of prothorax and also a triangular horn like tubercles appearing from the third quarter of the same mid-dorsal surface of prothorax.. **Abdomen** : Abdominal tubercles more prominent, stout and elongated than second instar, additional setae occurring on these tubercles.

Fourth instar: 1.23 mm long ; 0.62 mm wide. Body shape and texture of integument similar to those of third instar. **Head** : 0.23 mm long ; 0.32 mm wide. Five armed tubercles more prominent than preceding stage; tubercles on the anterior end of head with numerous trumpet shaped setae, biramous tubercles on the median-dorsal line which consist of numerous trumpet shaped setae, posterior pair of tubercles of each side of temporal with numerous trumpet shaped setae. Eyes prominent with more than eighteen compact ommatidia. Antenna 0.73 mm long, segment IV longer than the post. The rostral tip extending up to end of mesosternum. **Thorax** : Prothorax longer than preceding stage. Tubercles on mid-dorsally of prothorax and mesothorax more stout and elongated than third instar. Mesothoracic wingpads extending up to abdominal segment II. Mesothorax covered by mesothoracic wingpads, caudo-lateral corners of wingpads, rounded; wingpads bearing one long and short tubercle on either margins; large caudo-lateral tubercles of pro- and mesothorax bearing numerous trumpet shaped setae. **Abdomen** : Similar to that of third instar, lateral tubercles on abdominal segments IV-IX with numerous trumpet shapes setae. Tubercles on abdominal segments VIII shorter than others. Tubercles on mid-dorsally of abdominal segments V, VI and VIII slightly longer than in preceding instars. Very minute tubercles appearing on lateral aspects of abdominal segments II and III.

Fifth instar: 1.65 mm long ; 0.79 mm wide. Body elliptical and dark yellowish. **Head** : 0.27 mm long ; 0.38 mm wide. A pair of anterior frontal tubercles surpassing the level of the anterior margin of the anteclypeus by atleast half its length. Median frontal tubercles larger and bilobed and occipital tubercles directed obliquely sideways (over the eyes), surrounded by more than ten setae. Eyes prominent with more than twenty five compact ommatidia. Rostral tip reaching up to the middle of the mesosternum. Antenna 1.12 mm long, segments I and II little broader than III and IV, segment IV longer than segment III;

numerous setae covering entire length of antenna. **Thorax** : Anterior margin of prothorax moderately concave, posterior margin produced into a triangular process; wingpads and prothoracic growth more pronounced: wingpads extending behind on each side a little beyond the posterior margin of abdominal segment IV; lateral sides of prothorax armed with two tubercles. Wing pads also bearing one long tubercle and three short tubercles on anterior-lateral margins. A pair of horn shaped tubercles (anterior region) and another triangularly horn shaped tubercles (posterior region well developed in the dorsomedian line of prothorax and a distinct pad formed at the base of these horns, tubercles devoid of setae or spines. **Abdomen** : Similar to that of fourth instar. Tubercles disappeared on abdominal segments II and III. Tubercles distributed over dorsally and dorso-laterally of abdominal segments, more elongated and stout than previous instar. Tubercles bearing additional setae increasing numerically. Patches of granules appear on dorsal surface of abdominal segments II – VII.

Adult: Male 2.05 mm long ; 0.82 mm wide; **Female** 2.12 mm long, 1.01 mm wide. Adults transparent, straw-yellow and when on the host plant, the green of the leaf shows through the tingids lacy hemelytra thus camouflaging. Head oval with 4-segmented antenna, 1.86 mm long; segment I 0.15 mm, segment II 0.08 mm, segment III 0.84 mm, segment IV 0.79 mm long in male and 1.86 mm long, segment I 0.17 mm, segment II 0.09 mm, segment III 0.79 mm, segment IV 0.76 mm long in female. Thorax curved by arch like membranous hollow expansions. The hemelytra extending far beyond the abdomen, thin and lace like with brilliant iridescence. The hemelytra and the hood with net like reticulations. The abdomen dark brown, narrowing backwards in the male wider in the female.

The immature stages of Tingidae are clothed with varieties of cuticular outgrowths (tubercles). The tubercles of the head so called “horns” are 4 or 5 in number, an anterior and a posterior pair, with or without single median tubercles are notable morphological characters. The process of the prothorax and abdomen and the smaller cuticular outgrowths present only in nymphs and vary in their number, degree of development and conspicuousness in different genera and species. All the cuticular outgrowths have taxonomic value (May, 1977). The body outgrowths have been described by many investigators and applied different terms for these spiniform processes. Crosby and Hadley (1915) applied the term tubercles for the structures on which are mounted the spines and the term “hair” for the simple outgrowths. Johnson (1936) also termed “tubercles” for the same structures. Roonwal (1955) used the

term “lobular prominences” for the same structure. Patel and Kulkarny (1955) called them “scoli” and “tubercles”. and Stusak and Stys (1959) reported on the functional significance of these body outgrowths. According to them they serve three functions namely (i) Aid the nymphs to cling firmly on the host plant by dovetailing among the ramified trichomes of the leaf; (ii) Protect the body against mechanical injuries and probably also against predators and parasites, and (iii) Concealment. In the present study detailed descriptions are made on all five nymphal instars in view of the fact that each nymphal stage exhibits morphological characters that are distinctive so as to fix the taxonomic status of the species concerned with certainty.

In the present study measurements of different body parts of nymphal and adult stages were made with a view to examine their significance in morphometry in the context of allometric growth patterns of *D. conchatus*. Certain body parts exhibit a positive allometry and certain others negative one and these aspects obviously differ in different species. Thus allometric growth pattern in tingids appear, as they are in several other groups of insects, to have a bearing on the taxonomy and help in the determination species at the nymphal stage itself.

2. Feeding and aggregation behaviour

This lace bug has shown an absolute host specificity being confined to *M. tinctoria*. The nymphs and adults feed from ventral surface of leaves. The early stage nymphs are gregarious. After eclosion, first instar nymphs form loose aggregations of less than 15 individuals which move from one feeding site to another after feeding. There is no segregation of the different nymphal instars. Fifth instars tend to disperse from the rest of the colony just before it moults into adult.

3. Mating and oviposition behaviour

The mating preludes and sequential behavioural pattern of tingids are known only to a limited extent. It was noticed from the present findings that males always right sided to females during copulation. The male would then grasp her, turn to a 30-90 degree angle and copulate. Repeated mating occurred and mating lasted 60 - 75 minutes. Sometimes two males attempted to mate with a single female in the laboratory as well as field observations. The mating pairs were mostly observed on upper, rather than lower leaf surface. Mating was

observed only during morning and evening hours. The process of mating is initiated by the male which approaches the female and flutters its wings for some time, before climbing the females. Antennal caressing by the male induces the female to open her elytra and expose her abdomen. The dorsal surface of the tip of the male abdomen was always in contact with ventral aspect of that of the female. Comparable type of mating behaviour has been reported for *Tingis buddleiae* (Livingstone, 1968), *T. ampliata* (Eguagie, 1973), *Habrochila laeta* (Asari, 1972) and *C. associata* (Sheeley and Yonke, 1977). Eguagie (1973) attributed that mating in *T. ampliata* occurred at any time from 08.00 to 21.00 hrs. It is noteworthy that in the present study also the mating behavior follows the main sequences as described by the above authors. However, time of mating, the duration of mating, the precopulatory period and intervals between successive matings or obviously species specific and depend to some extent on the ambient physical environmental factors that may also play a role in the fecundity of the tingids and these aspects have not been investigated.

Females of *D. conchatus* usually laid their eggs on leaves not damaged by feeding. They were laid singly, rarely in groups up to 4 at the heavy juncture of the midveins and side veins in the basal half of the leaf on the ventral surface. (Table 3). The eggs were laid at right angles to plant tissues with their basal ends slightly inserted into the plant tissues. The eggs were unevenly distributed along leaf mid rib. The lace bug inserts eggs into leaf tissues almost up to the opercular cap. The small neck portion of the egg is exposed above the leaf surface. No secretion was applied over them as they were supported and concealed by the plant pubescence. Often, one third to three quarters of the egg was exposed above the epidermis. Occasionally an egg may be deposited unembedded between the felty hairs in between midveins and leaf surface on the adaxial surface. It rarely laid their eggs on the upper surface. Midribs and other branches of veins were usually preferred for egg laying. Livingstone and Yacoob (1987) stated that majority of tingids prefer the ventral surface for safety and protection from direct exposure to sun light. It has also the advantage to the safety of the nymphs from predation and from being directly exposed to insecticides. Most of the eggs are inserted into midrib and other veins of abaxial surfaces. *M. tinctoria* has large midribs and distinctly prominent primary and secondary veins which may be probably associated with *D. conchatus* oviposition preference. On the other hand, by laying some eggs in interveinous spaces, *D. conchatus* differs from species such as the rhododendron lacebug, *Leptobyrsa rhododendri*, which rarely uses such sites (Johnson, 1936).

4. Life cycle of *Dulinius conchatus* (Tables 4 and 5)

Duration of egg : The average duration of egg was 8.4 ± 0.2 days, which ranged from 8-9 days.

Duration of nymphs : The total duration of five nymphal stages was 11.8 days, with a range of 10-12 days. The mean duration of I, II, III, IV and V nymphal instars were 2.8, 1.7, 2.0, 2.3 and 3.0 days, respectively. Second instar took the shortest period of 1.7 days, whereas fifth instar completed development in 3.0 days. The life cycle from egg to adult was 20.2 days.

Pre-and-post oviposition period : Pre-and-post oviposition period was 3.2 and 3.1 days, respectively. The mean oviposition period lasted 17.6 days, with a range of 9 – 23 days.

Longevity : In the laboratory, males lived on an average for 20.2 ± 1.4 days, with a range of 12 – 26 days, whereas for females, it was 23.2 ± 1.9 days, with a range of 14 – 30 days. In all cases females lived longer than males.

Fecundity : The fecundity rate for ten females of *D. conchatus* varied from 85 - 208 eggs, with an average of 150.7 ± 12.6 .

Behaviour of adults : This lace bug is very poor in flight and dispersal as other tingids. It feeds and lives in the same host plant. Flight occurred from leaf to leaf during dusk only. Adults usually do fly away when disturbed but move only little distance on leaf surface.

5. Population dynamics

The total number of eggs, nymphs and adults of *D. conchatus* on *M. tinctoria* and the meteorological data for the years 1990-1991 are given in tables 6 and 7.

The data revealed that the total population of *D. conchatus* on its host plant was very low during May, June and October and during remaining periods the population was sustained well. However, the peak population (nymphs, adults) recorded in August was followed by a decline in population level in other months. During the year 1991, field population was found to be higher during April as well as August – September and declined thereafter.

Population was the lowest during December after heavy heavy rainfall but some residual population was always left on young leaves.

The results of correlation worked out to assess the relationship between the weather factors and the population level of *D. conchatus* are furnished in Table 8. It is highlighted that the increase in the total number of nymphs and adults of *D. conchatus* is significant with increase in maximum temperature, though it exhibited a negative relationship with humidity and rainfall in the period of two years.

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Table 1. Morphometric measurements (mm) of *Dulinius conchatus* (numbers indicate average of five individuals)

Morphological Character	Nymphal Stage					Adult	
	I	II	III	IV	V	Male	Female
Total body length	0.49 ± 0.01	0.65 ± 0.01	0.89 ± 0.01	1.23 ± 0.02	1.65 ± 0.02	2.05 ± 0.07	2.12 ± 0.07
Head length	0.11 ± 0.00	0.15 ± 0.00	0.18 ± 0.01	0.23 ± 0.00	0.27 ± 0.01	0.30 ± 0.00	0.33 ± 0.01
Head width	0.15 ± 0.00	0.19 ± 0.00	0.27 ± 0.01	0.32 ± 0.01	0.38 ± 0.01	0.38 ± 0.01	0.39 ± 0.01
Prothorax length	0.12 ± 0.00	0.17 ± 0.01	0.20 ± 0.01	0.27 ± 0.01	0.52 ± 0.02	0.59 ± 0.01	0.68 ± 0.02
Prothorax width	0.21 ± 0.01	0.29 ± 0.01	0.36 ± 0.01	0.53 ± 0.01	0.82 ± 0.02	0.70 ± 0.01	0.77 ± 0.02
Abdomen length	0.29 ± 0.01	0.36 ± 0.01	0.48 ± 0.01	0.73 ± 0.02	0.85 ± 0.03	1.14 ± 0.01	1.17 ± 0.07
Abdomen width	0.26 ± 0.01	0.32 ± 0.01	0.43 ± 0.01	0.62 ± 0.01	0.79 ± 0.03	0.82 ± 0.01	1.01 ± 0.03
Rostrum length	0.23 ± 0.00	0.32 ± 0.01	0.35 ± 0.01	0.49 ± 0.01	0.64 ± 0.01	0.73 ± 0.01	0.76 ± 0.02
Antenna total length	0.26 ± 0.00	0.35 ± 0.01	0.50 ± 0.01	0.73 ± 0.01	1.13 ± 0.03	1.86 ± 0.01	1.86 ± 0.01
Length of I segment	0.04 ± 0.00	0.04 ± 0.00	0.05 ± 0.01	0.08 ± 0.00	0.10 ± 0.01	0.15 ± 0.00	0.17 ± 0.01
Length of II segment	0.02 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.08 ± 0.00	0.08 ± 0.00	0.09 ± 0.01
Length of III segment	0.08 ± 0.00	0.11 ± 0.00	0.19 ± 0.00	0.26 ± 0.00	0.44 ± 0.12	0.84 ± 0.01	0.79 ± 0.03
Length of IV segment	0.12 ± 0.00	0.15 ± 0.00	0.23 ± 0.00	0.35 ± 0.01	0.52 ± 0.02	0.79 ± 0.00	0.76 ± 0.02
Wingpad length	-	-	0.11 ± 0.00	0.29 ± 0.01	0.68 ± 0.01	-	-
Wingpad width	-	-	0.09 ± 0.01	0.18 ± 0.01	0.37 ± 0.01	-	-
Length of hind femur	0.11 ± 0.00	0.17 ± 0.07	0.22 ± 0.01	0.32 ± 0.01	0.45 ± 0.00	0.70 ± 0.01	0.74 ± 0.02
Length of hind tibia	0.10 ± 0.00	0.14 ± 0.00	0.17 ± 0.01	0.29 ± 0.07	0.47 ± 0.01	0.75 ± 0.00	0.77 ± 0.0
Length of hind tarsus	0.08 ± 0.00	0.08 ± 0.00	0.11 ± 0.00	0.15 ± 0.00	0.15 ± 0.00	0.15 ± 0.00	0.15 ± 0.00

Table 2. Allometric Growth pattern of body parts in relation to total body length in *Dulinius conchatus*

Morophological Characters	Growth Ratio (K)		Initial growth index	
	Male	Female	Male	Female
Head length	0.12	0.13	0.07	0.06
Head width	0.15	0.15	0.11	0.11
Prothorax length	0.34	0.35	-0.09	-0.08
Prothroax width	0.38	0.39	0.05	0.04
Abdomen length	0.54	0.54	0.03	0.01
Abdomen width	0.38	0.46	0.10	0.04
Rostrum length	0.31	0.31	0.10	0.10
Antenna total length	1.12	0.95	-0.49	-0.31
Length of I segment	0.07	0.08	-0.01	-0.01
Length of II segment	0.04	0.05	0.03	-0.01
Length of III segment	0.45	0.42	-0.20	-0.18
Length of IV segment	0.41	0.39	0.12	-0.08
Length of hind femur	0.35	0.36	-0.05	-0.09
Length of hind tibia	0.41	0.41	-0.16	-0.15
Length of hind tarsus	0.05	0.04	0.06	0.07

Table 3. Distribution of eggs of *Dulinius conchatus* on the adaxial surface of Morinda leaf.

Leaf no.	Midribs	Primary vein	Sec. vein	Interv. space	Total
1	39	5	2	0	46
2	15	4	0	0	19
3	8	6	0	0	14
4	27	7	1	1	36
5	42	3	1	1	46
6	16	2	1	2	21
7	20	4	0	0	24
8	5	3	1	1	10
9	12	3	0	0	15
10	9	0	0	0	9
Total	193	37	6	5	241
Mean	19.3	3.7	0.6	0.5	24.1
%	80.1	15.4	2.49	2.1	-

Table 4. Duration of each immature stages of *Dulinius conchatus*

Stage	numbers completing stadium	Range	Mean \pm S.E	Cumulative mean age
Egg	68	8-9	8.4 \pm 0.2	8.4
I instar	59	2-3	2.8 \pm 0.1	11.2
II instar	52	1-2	1.7 \pm 0.1	12.9
III instar	49	1-2	2.0 \pm 0.1	14.9
IV instar	48	2-3	2.3 \pm 0.1	17.2
V instar	48	3-4	3.0 \pm 0.1	20.2

Table 5. Pre-and post-oviposition periods, longevity and fecundity of *Dulinius conchatus*

		Range	Mean \pm S.E
Pre-oviposition periods		2 -4	3.2 \pm 0.2
Oviposition periods		9 23	17.6 \pm 1.7
Post-oviposition periods		1 -7	3.1 \pm 0.7
Adult longevity	Male	12 -26	20.2 \pm 1.4
	Female	14 -30	23.2 \pm 1.9
Fecundity		85 -208	150.7 \pm 12.6

Table 6. Population dynamics of *Dulinius conchatus* on *Morinda tinctoria* for the year 1990

Period	Temperature		Rainfall mm	RH%	Egg	Nymphs	Adults	Total
	Max.	Min.						
January	29.8	19.5	006.7	80.7	111	59	22	81
February	31.3	23.1	002.9	79.7	210	150	16	166
March	32.9	25.6	002.0	77.2	379	239	71	310
April	34.6	27.2	000.0	73.8	589	350	122	472
May	34.6	26.3	408.5	74.2	89	18	5	23
June	36.1	27.4	020.3	64.0	21	7	4	11
July	35.1	25.9	096.7	68.5	295	82	88	170
August	34.9	25.9	055.7	65.5	812	728	227	955
September	34.3	25.4	195.0	75.5	691	320	93	413
October	34.9	24.8	573.5	80.5	128	12	7	19
November	30.0	23.3	309.3	78.0	232	42	28	70
December	28.9	22.9	091.9	76.5	196	96	28	124

Table 7. Population dynamics of *Dulinius conchatus* on *Morinda tinctoria* for the year 1991

Period	Temperature		Rainfall mm	RH%	Egg	Nymphs	Adults	Total
	Max.	Min.						
January	29.4	21.9	004.0	83	97	20	16	36
February	31.6	22.1	001.0	78	168	79	18	97
March	32.5	24.3	000.0	76	385	194	68	262
April	34.8	26.9	000.0	71	697	666	148	814
May	36.1	28.4	000.0	71	36	61	33	94
June	34.3	26.1	091.0	75	84	112	62	174
July	34.6	26.6	000.0	71	146	75	14	89
August	34.1	25.9	002.0	75	901	488	140	628
September	34.3	25.8	003.4	79	953	471	159	630
October	32.1	24.1	006.3	83	416	223	75	298
November	29.5	23.0	320.2	85	56	53	16	69
December	28.9	21.8	465.1	79	42	14	3	17

Table 8. Correlation between abiotic factors and the population of *Dulinius conchatus*

		Simple correlation				Multiple Correlation
		Temperature (°C)		Rainfall (mm)	Relative Humidity	
		Max.	Min.			
1990	Nymphs	0.3087	0.2701	-0.3719	-0.2631	0.3666
	Adults	0.3580	0.3371	-0.3454	-0.4671	0.4974
	Total	0.3236	0.2889	-0.3655	-0.3157	0.3960
1991	Nymphs	0.4673	0.5341*	-0.3961 *	-0.3742*	0.7241**
	Adults	0.5416*	0.6099**	-0.4348*	-0.3599*	0.6745**
	Total	0.5057*	0.4651	-0.3441*	-0.3768*	0.7141**

* Significant at 5 % level; ** Significant at 1% level. Noni Symposium on Noni for Health and Wellness, Chennai.

Figure 1. Egg and Nymphal stages of *Dulinius conchatus*
 1.Egg, 2. First instar, 3. Second instar, 4. Third instar, 5. Fourth instar, 6. Fifth instar

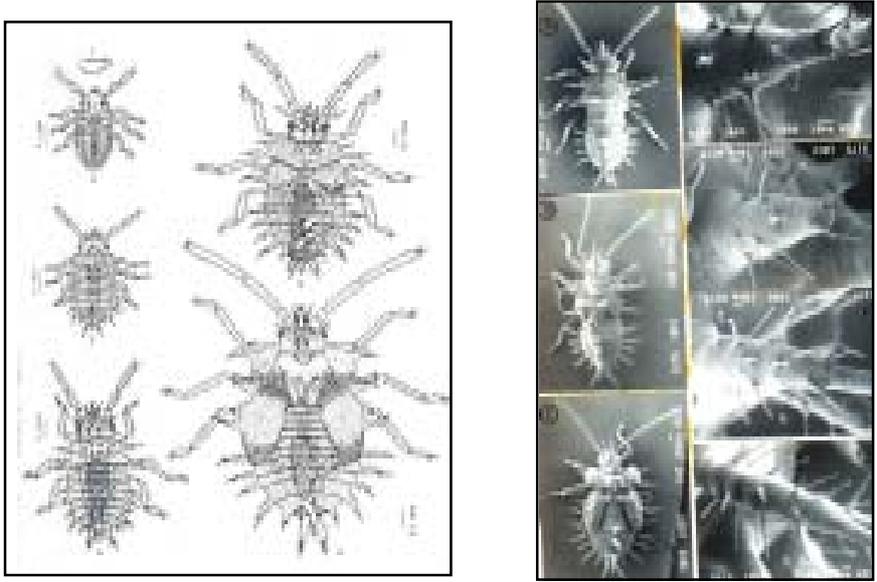


Plate 1. Scanning electron micrographs of: A- III instar, B- IV instar,, C- V instar nymphs;
 D- tubercle on mid dorsal surface of abdominal segment VI ; E – on abdominal segment VIII of 3rd instar;
 F – tubercle on mid dorsal surface on abdominal segment VII of 4th instar ; G- of 5th instar nymph.

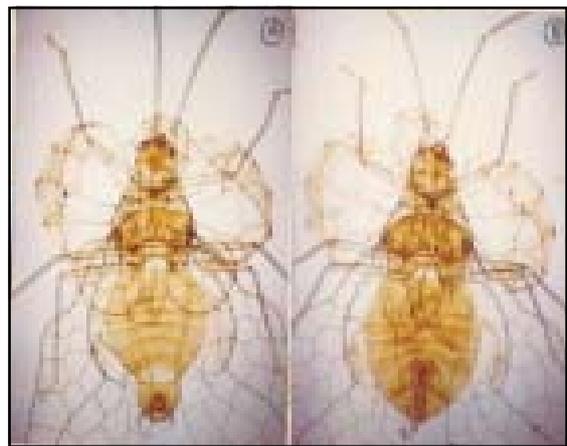


Figure 2. Adults of *Dulinius conchatus* : A: Male B: Female

Evaluation of *Morinda citrifolia* L. (Noni) extract on production and immune response in poultry

Jai Sunder, D.R.Singh and A.Kundu

Abstract

Morinda citrifolia L. is commonly known as Noni and is being used worldwide for its therapeutic and medicinal properties. Almost all parts of the plant are being used for its medicinal and nutraceutical properties. There is great demand for its fruit juice in alternative medicine for different kind of illness. However, very little research has been conducted on its effect on animals and poultry. Because of its various nutritional and medicinal benefits it is very important to know the effect of feeding of *Morinda* extract in poultry. Hence, the study was conducted to assess the production performance and immunomodulatory properties *Morinda citrifolia* L. extract in poultry. The studies was conducted in Nicobari fowl, an indigenous poultry bird of this islands. The birds were fed @ 5% crude leaf extract from day old till eight week of age. Control group of birds were provided with only basal ration. The birds were maintained under deep litter system and throughout the experiment no medication or additional supplements were fed except the normal basal ration. During the experiments, body weight, FCR, and growth parameters were observed. The humoral immune response was assessed by injecting GRBCs and cellular mediated immune response by injecting PHA-P. The sera samples from birds were collected at weekly intervals to assess the antibody response. During the experiment phase mortality percentage was also recorded. The results of the leaf extract studies revealed no significant difference in terms of body weight gain, FCR, feed efficiency and performance index in both the groups. There was no

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significant difference observed in terms of FCR in both the group but the FCR of the Morinda group (3.9±0.5) was recorded better than control group (4.1±0.5). The overall performance index of Morinda group (20±3.5) and control group (21±4.4) did not differ significantly. The HA titer values in Morinda fed group (6.5±6.2) was found to be significantly higher (p<0.05) than control (1.02±0.9). No significant T cell response was observed in both the groups.

Introduction

The *Morinda citrifolia* L. belongs to the family Rubiaceae, is present worldwide and more predominately in tropical countries. It is considered to be important traditional folk medicinal plant, having broad range of therapeutic and nutritional value (Whistler, 1992). Noni is the common name for *Morinda citrifolia* L. and is also called as Indian mulberry, Ba Ji Tian, Nono or Nonu, Cheese fruit and Nhau in various cultures throughout the world. The roots, stem, bark, leaves, flowers and fruits of the Noni plant are all involved in various combination in almost 40 known and recorded herbal remedies (Bruggnecate, 1992). There is a great demand for its fruit juice in alternative medicine for different kinds of illnesses such as diabetes, high blood pressure, muscle aches, menstrual difficulties, headaches, heart disease, cancers, gastric ulcers, sprains, mental depression, senility, diarrhea, arteriosclerosis, Poor digestion, blood vessel problems and drug addiction (Wang et al., 2002).

Scientific evidence of the benefit of the Noni fruit juice is limited but there is some anecdotal evidence for successful treatment of cold and influenza (Solomon, 1999). Allen and London (1873) reported some ethno botanical properties of Noni. Duncun et al., 1998 demonstrated that scopoletin, a health promoter in Noni. There are several components identified in the Noni plant such as scopoletin, octanoic acid, Vitamin K, Vitamin C, terpenoids, alkaloids, anthraquinones, B-sitosterol, carotene, Vitamin A, linoleic acid, amino acid, acubin, caproid acid, caprylic acid etc. (Levand and Larson, 1979, Moorthy and Reddy, 1970, Heinicke, 1985). Bushnell *et al.*, 1950 reported that Noni was a traditional remedy used to treat broken bones, deep cuts, bruises, sores, and wounds. Morton (1992) gave numerous references for medicinal uses of Noni. In addition, Polynesians have successfully used Noni to treat breast cancer and eye problems. Joseph Betz (1997), a research chemist in the FDA's Division

of Natural Products, Center for Food Safety and Applied Nutrition, stated, “*Morinda citrifolia* L. has been tested for a number of biological activities in animal and anti-microbial studies.” He also reported that the dried fruit has smooth muscle stimulatory activity and histaminergic effects. There are very few reports available on animal model. In the present study the effect of feeding *Morinda citrifolia* leaf extract on production and immune response of poultry was studied. The humoral and cellular mediated immune response was assessed in the poultry fed with crude fruit and leaf extract of *M. citrifolia*.

Materials and Methods

The leaf of *Morinda citrifolia* L., was grounded and then sieved to get the extract. The extract was fed to the poultry by mixing it @ 5% in drinking water. A total of old day 50 Nicobari chicks (Black, White & Brown) were used for the experiment. The birds are divided into two subgroups with 25 birds in each group. The experiment was conducted till eight week of age of the poultry birds.

Group A: Control fed with normal basal ration

Group B: Morinda leaf extract supplement @ 5 % in the water with normal basal ration

All the birds were maintained under standard deep litter system of rearing and fed with normal chick ration. Standard feeding and managemental conditions were precisely followed. Fresh water was given ad libitum during the whole experimental period. No medication, antibiotics, dewormer etc were given to the birds. Daily mortality, health status were also noted in all the groups. Daily mortality and health status were also noted in all the groups. The body weight gain, FCR and performance index and production of number of all the groups were recorded. Daily mortality and health status were also noted in all the groups. The body weight gain, FCR and performance index {live weight (g)/FCR} of all the groups were recorded. The production number was calculated for all the genetic groups by employing the formula :

$$\text{Production number.} = \frac{\text{Average Live weight} \times \text{Survivability (\%)}}{\text{Days} \times \text{FCR}}$$

Humoral immune response :

The method of Siegel and Gross (1980) with slight modification was followed for assaying the immune response to goat red blood cells (GRBCs). To assess the humoral immune response the haemagglutination test (HAT) was conducted with GRBC in the experimental birds. The goat RBC was used as an antigen and 2% suspension was prepared in PBS (pH-7.2) and injected into wing vein of the birds @ 0.25 ml per bird through I/V route. The blood samples before the injection and at every week interval were taken from each bird till eighth week of age. The sera samples were separated and were assessed for presence of anti GRBC antibodies by HA test. The HA test was carried out in 96 well U shaped microtitre plate. In all the wells 25ml of PBS was added, then in the first well 25ml of test sera was added and double fold dilution was made in the respective wells. Then 25 ml of freshly prepared 2% GRBC was added into all the wells and mixed properly. In the control wells only 25 ml of 2% GRBC was added. The plate was then incubated at 37^o C for 1-2 hr. The plate was read for of button formation and mat. The formation of the button was considered as negative. The titer was expressed as the log₂ of the reciprocal of the highest dilution giving visual agglutination (button formation) and the data were statistically analyzed.

Cellular mediated immune response :

The in-vivo cell mediated immune response to PHA-P (Phytohaemagglutinin) was evaluated by the method of Cheng and Lamont (1988). PHA-P is used in its mucopolysaccharide form from the red kidney bean, *Phaseolus vulgaris*. . Good responder to PHA-P means a higher general level of cellular immunity influencing T-cell mechanisms restricting or preventing lymphoma formation. The PHA-P (0.1 mg/ml in PBS) @ of 0.1 ml was injected interdigitally between the third and fourth toe of the right foot of the chicken. The left foot served as control and was injected with 0.1 ml of PBS. The skin index was calculated as the difference between the swelling in the right minus left foot, before and 24 hrs after the injection and expressed as millimeter.

$$F1 \text{ (mm)} = (\text{Post inj.} - \text{Pre inj.}) - (\text{Post PBS- Pre PBS})$$

Where, post inj. is thickness of test foot 24 hours post injection of PHA-P.

Pre inj. is thickness of test foot pre-injection.

Post PBS is thickness of control foot 24 hours post injection of PBS and

Pre PBS is thickness of control foot before injection.

Results and Discussion

The growth performances in terms of body weight gain, FCR, feed efficiency and performance index at weekly interval of both the groups are presented in the table 1. The overall results revealed a higher body weight gain in control group (69.4 ± 10.1) than in Morinda fed group (65.5 ± 8.1). However, no significant difference was recorded in terms of body weight gain, FCR, feed efficiency and performance index in the both the control and Morinda fed group. However, no significant difference was recorded in terms of FCR in both the group but the FCR of the Morinda group was recorded better than control group.

The overall performance index of Morinda group and control group was also did not differ significantly. The results of the HA test with means along with standard errors for antibody response (HA titer) are given in table 2. The results revealed the appearance of antibody in both the groups on first and second week of immunization. The antibody titer reaches its peak at one week PI in both the groups. The average HA titer values in Morinda fed group (6.5 ± 6.2) was found to be significantly higher ($p < 0.05$) than control group (1.02 ± 0.9). The cellular mediated immune response showed no significant T cell response in both the groups. The values were group A (0.43 ± 0.09) and B (0.58 ± 0.02), group respectively. No significant T cell response was observed in both the groups; however, higher T cell response was observed in the Morinda fed group.

The research reports the several use of therapeutic and nutritional use of *M. citrifolia* (Singh et al., 1984). Literatures also indicates that noni increases the defenses and reinforces the immune system of the body, neutralize its function in all the cells and regenerates the affected cells (Heinicke, 1985.). Noni was also capable of stimulating the release of several mediators from murine effector cells, interleukin-1beta (IL-1), IL-10, IL-12, inter feron-gamma (IFNs) and nitric oxide (NO) (Hirazamu and Firusawa, 1999). In the present study both humoral and cellular immunity has been increased by the Morinda citrifloia. There are reports that it acts with other antioxidants jointly and helps to prevent diseases. As the immune level was found to be increased in the morinda fed groups. There are several reports

that indicate the therapeutic and health effect of *Morinda citrifolia* L., however, no report is available on effect in animals and in birds. In the present study the effect on growth and overall performance were studied and found to be better in morinda fed group. As it has been used to treat various common diseases and to maintain overall good health (Krauss, 1993).

Locher *et al.*, 1995 reported that selected plants including *Morinda citrifolia* L., have a history of use in Polynesian traditional medicine for the treatments of infectious disease. The present study revealed the overall nutritional effect and immune enhancer effect of *M. citrifolia* in poultry. However, further investigation on several bioactive compounds present in the *M. citrifolia* will help in understanding the actual mechanism in detail.

Based on the preliminary studies on the effect of feeding *Morinda citrifolia* L., extract on production and immune response status of the poultry birds, it is evident that the leaf extract has got both beneficial effect in terms of eliciting immune response in poultry. However, further examination on the alkaloid contents and phytochemicals of the *M. citrifolia* is required to understand the active principles.

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Table 1. Growth performances of the different group of birds (Nicobari fowl) fed with leaf extract.

Week	Body weight gain		Feed Conversion Ratio		Performance Index	
	Control	Morinda	Control	Morinda	Control	Morinda
0-4	44.8±7.3	43.3±10.8	2.6±0.3	2.7±0.4	18.6±4.5	18.7±7.4
4-8	76±19.1	74.3±15.5	4.6±1.0	4.5±1.2	21.3±8.8	21.5±7.5
8-12	87.5±19.5	79±11	5±1.1	4.4±0.8	23.2±10.3	19.8±4.4
0-12	69.4±10.1	65.5±8.1	4.1±0.5	3.9±0.5	21±4.4	20±3.5

Table 2. Means and standard errors of HA titer (log₂) of different group of birds fed with leaf extract.

Week	Control	Morinda
0	0	0
1	4.6	31.4
2	0.5	1.12
3	0	0
4	0	0
Avg.	1.02±0.9	6.5±6.2

Development of Noni (*Morinda citrifolia*, L.) based Nutraceuticals for Health Security

P.N. Satwadhar¹, A.N.Siddiqui¹ and H.W.Deshpande¹

Abstract

Processing of noni fruits depends on harvesting indices and intended processing methods. Most of noni juice processors accept or prefer the 'hard white' stage of fruit development for noni juice production as fruits ripen quickly when picked at that stage. The extraction efficiency of juice by traditional or drip extraction method accounted nearly 40%-50% of original fruit weight. A variation of traditional drip-extraction method produces a non-fermented, sweet juice, which is preferred by consumers. Moreover, the non-traditional noni juice extraction method suggest the juice recovery upto 65% with sweeter (less acidic), fruitier flavour and non fermented noni juice.

There is an urgent need to utilize noni fruit juice for the preparation of value added products such as squash, prash, flavoured beverages (RTS), diet noni (low calorie beverages), syrups, leather and bar etc., which are having commercial values in the market. Moreover the noni fruits could be exploited for fruit power, crush, toffee and fortification with other foods also i.e. ice creams and herbal teas. So technologies should be standardized for the preparation of value added products which can be easily available at cheaper cost, so that common masses can equally able to entitled the nutraceuticals and medicinal benefits of the wonderful gift of nature. One of primary challenges to food technologist is to effectively translate beneficial traditional folk remedy into shelf stable product. So at present the processing methods used for noni fruits products ensure retention of greater concentration of active, volatile constituents.

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Further, whatever the technologies were developed, must be assessed for their techno-economic feasibilities, so that they disseminated to masses to become promising entrepreneur. It will results to open a new avenue for farmers/ unemployed youth/ rural women to start their own agribusiness at their village level.

Introduction

Over the past few years as natural products have become increasingly popular, the field of natural herbal remedies has flourished. Today botanical products from various continents and cultures are sold in health food stores, drug stores and supermarkets, in catalogs and via the Internet, to an eager, receptive public seeking safe, effective alternatives to drugs. One up-and-coming botanical, the fruit of *Morinda citrifolia*, whose Polynesian name is noni, is currently the subject of much science, myth, and marketing hype. Noni was first discovered and used by man long before recorded history in Southeast Asia and the subcontinent, when ancient Indian scientists began examining their natural world to find plants good not only for food, but to treat disease and otherwise benefit their health. They developed a medical system of using plants and natural treatments to influence their health and called it Ayurveda, Sanskrit for “the science of life.” A highly advanced system of natural medicine, Ayurveda is still practiced today. Noni was considered a sacred plant and is mentioned in ancient texts as Ashyuka, which is Sanskrit for “longevity.” Noni was noted to be a balancing agent, stabilizing the body in perfect health.

Today noni ranges from Tahiti to India and grows in the Caribbean, South America and the West Indies. Its broad dispersal speaks of its value to traditional cultures. The name “noni” is Polynesian. Some marketers erroneously claim that Polynesian noni is a different species from Indian Noni *Morinda citrifolia*, or Indian Mulberry. This is wholly untrue. From one culture to another the plant is the same. There are three known varieties of noni such as *Morinda citrifolia* var. *citrifolia*, large-fruited and small-fruited members of this group exist in Pacific region. *Morinda citrifolia* var. *bracteata* is a small-fruited variety with conspicuous bracts found in Indonesia and other parts of the region between the Indian and Pacific Oceans. *Morinda citrifolia* cultivar ‘Potteri’ is an ornamental type, with green and white leaf variegation, distributed throughout the Pacific.

Medicinal Properties

Medicinal value is found thorough the plant. Its leaves, flowers, roots, bark and stalks were traditionally used to treat various and wide range of disease, but it is the fruit, which stores the essence of the plant. Noni fruit contains 140 plus neutraceuticals and other medicinal active constituents including enzymes, alkaloid, anthraquinones, damnacanthal, phytonutrients, minerals and vitamins, which are identified so far in the Noni juice. According to bioscientific investigations of noni fruit conducted over the past fifty years, ripe noni fruit, extracts of ripe noni fruit, and constituents found in ripe noni fruit demonstrate a plethora of biological activities. The various theurapeutic and medicinal benefits of Noni include antiseptic, bactericide, fungicide, antiinflammatory, laxative, antioxidant, anesthetic, candidacide, cathartic, analgesic, detoxicant, anticancer, antitumor, hypercholesterolemic, Antiarteriosclerotic, hepatoprotective, immunomodulatory, antifibrinolytic, antiedemic, Cleansing and purgative activity. In cases of sluggish digestion and slow moving bowels, noni can exert a stimulating and thereby beneficial effect, helping to increase peristalsis and cleanse the colon.

Noni can cure Addictions, Aging, AIDS, Allergies, Asthma, Atherosclerosis, Blood Vessel, Broken Bones, Burns, Bruises, Cancers, Catarats, Cell Regeneration, Chronic Back Pain, Chronic Fatigue, Colitis, Cuts, Depression, Detoxification, Diabetes, Digestive Problems, Energy Boost, Fibromyalgia, Headache and Migraine, Heart Disease, Stroke, High Blood Pressure, High Cholesterol, Immunity-T Cell Count, Increase Energy, Infectious Diseases, Inflammation, Insomnia, Intestinal Parasites, Kidney Health, Lupus, Menstrual cramps, Multiple Sclerosis, Weight Problem-Over/Under Weight, Osteoarthritis, Pain, Psoriasis, Crohn's Disease, Respiratory Aliments, Senility, Sexual Vitality, Sinus, Tumor, tuberculosis Skin Problems-Eczema, acnes, etc.

Harvesting and processing requirements :

Noni fruits can be picked at any stage of development, depending on the intended processing method. Some producers prefer green fruits, whereas other processors prefer the hard white noni fruits for processing. Most noni juice processors accept or prefer the "hard white" stage of fruit development for noni juice production, because the fruits ripen quickly once that stage of development is reached. Noni fruits are harvested by hand by picking the individual

fruits from the branches. When picking noni fruits from wild plants, take care not to damage or break the extremely brittle branches of the noni plant. They are placed in baskets or bags or placed in bins for transport to the processing facility. Noni fruits do not bruise or damage easily, and usually no special padded containers or other precautions are needed to prevent significant fruit damage. Furthermore, exposure of noni fruits to direct sunlight or to warm temperatures immediately after harvest is not a significant concern. So, noni fruits need not be refrigerated after harvest and are usually not refrigerated. Fruits are washed at the processing facility before they ripen fully and turn soft. For juice production, the noni fruits are held at ambient or room temperature for 1 to several days to ripen before they are processed. However, prompt processing for juice is important, for if ripe fruits are allowed to sit for an extended period, they begin attract unwanted fruit flies, rats and other insects or pests. For processing of noni fruits for powders or other precuts, the fruits may be processed immediately, before they fully ripen. Unripe fruits are easier to work with some types of chopping and drying equipment.

The fruits are edible, but don't have a nice taste or smell. In fact, some people consider the ripe fruits to smell like vomit! Nevertheless, the fruits were eaten as a famine food, and in some Pacific islands, are even a staple food of choice (Raratonga, Samoa, Fiji), where they were eaten raw or cooked. Elsewhere, the fruit is eaten raw with salt (Indochina, Australian Aborigines); or cooked as a curry. The fruits may also be fed to pig livestock. The young leaves can also be eaten as a vegetable and contain protein (4-6%). Seeds may be roasted and eaten. Mature leaves are wrapped around fish before cooking and then eaten with the cooked fish. The terminal bud is used as food (e.g., Kiribati). Dried leaves or fruits are used to make infusions and teas for medicinal use.

One of the primary challenges in the field of botanical medicines is to effectively translate a beneficial traditional folk remedy into a beneficial shelf stable product. Traditionally, ripe noni fruit is put into a container, where it quickly decomposes and ferments. The pungent amber juice, which remains at the top of the fermented fruit is consumed daily as a prophylactic, to enhance overall vitality and well being. Most people cannot obtain fresh fermented ripe noni juice. Therefore natural, fresh noni juice is needed to be translated effectively into shelf-stable dietary supplements. The five enemies of all natural products are heat, light, air, moisture and time. Any process of noni preparation must minimize these

factors, especially considering that the volatile constituents are unstable and are easily reduced or destroyed. While drying noni fruit yields a material that can be powdered and put into dietary supplements, this process subjects the fruit to all five destructive factors. Bottled noni juices undergo pasteurization to eliminate the problem of microbial contamination. During pasteurization, volatile constituents are inevitably reduced. At present the processing method most likely to yield a beneficial noni fruit product is lyophilization (freeze-drying). This process avoids the five destructive factors, producing a stable material, which retains a greater concentration of active, volatile constituents.

Processed Noni products

Noni Juice

Noni fruit juice and juice products are processed and prepared by a variety of methods. For example, noni juice may be fermented versus unfermented, or fresh-squeezed versus drip-extracted. The “traditional” juice is both drip-extracted and fermented/aged for at least two months. The “non-traditional” method of juice extraction is by pressing or squeezing the juice from ripe fruits. Noni juices may be amended with other additives or diluted, or bottled in its pure state. It may be bottled with or without pasteurization. Noni juice can be more popularised in the form of following beverages

- **(RTS)Ready to serve beverage** : This is the ready to serve Noni juice to which sugar has been added.
- **Squash** : Noni squash is prepared by increasing the TSS of noni juice and diluted before serving.
- **Concentrated liquid**: Concentrated Noni juice may contain added sugars in such proportions to ensure that when reconstituted according to the directions stated on the label, the reconstituted juice complies with this compositional guideline.
- **Flavoured beverage**: Since the pure Noni juice has unpleasant aroma and taste, it can be improved by incorporating flavoured spices and herbs like mint, Ginger cardamom, vanilla etc. Some synthetic flavours and essence can also improve the flavour to acceptable

level. Taste can be modified by addition of sugar, honey or non-nutritive sweetener, low cost steavia etc.

- **Fortified beverage:** It is the Noni juice beverage fortified with vitamin supplements and minerals.
- **Mixed or blended juice:** Noni juice can be mixed with other fruit juices like grape juice, pomegranate juice, jamun juice, sweet orange juice etc.
- **Diet Noni Juice:** It is a low calorie Noni juice in which sugar is replaced by adding non-nutritive sweetener like aspartame, steaviocides, saccharine etc.
- **Wine:** It is alcoholic beverage prepared from Noni juice.
- **Sweetened concentrated Noni juice and Sweetened reconstituted Noni juice** are respectively concentrated Noni juice and reconstituted Noni juice to which sugars have been added in accordance with the compositional guideline.
- **Herbal drink:** This type of drink can be prepared by adding natural herbs or their extract like safflower extract, Roselle extract, Aloe vera juice, grape seed extract, camellia extract etc.

Noni Pulp: It can be exploited in preparation of novel foods like

- **Fruit leather bar :** Noni pulp can be successfully employed for preparation of leather bar. The pulp can be used alone or mixed with other fruit pulp like apple, mango, papaya, sapota and other pulpy fruit for better taste and acceptability.
- **Sweet pulp concentrate :** It is a novel product of Noni fruit pulp where TSS and acidity is adjusted to obtained desired sugar acid ratio and pulp is homogenized.
- **Herbal prash :** Noni pulp can be well mixed with some popular Indian herbs and spices to give a relishing and laxative product “herbal prash”.
- **Mixed fruit prash :** Noni pulp can also be mixed in definite proportion with other fruit pulp like aonla, date, fig, papaya, guava, apple etc. along with herbs and spices to prepare mixed fruit prash.

- **Puree** : It is a similar product to noni sweet pulp concentrate, differ in added ingredients and flow characteristics.
- **Jam, Spread, Mixed fruit jam**: Noni pulp is rich in pectin hence can be converted to jam, spread and mixed fruit jam like other fruit jam.
- **Powder** : Noni pulp can be converted to free flowing powder by spray drying or drum drying. Dried Noni fruit also yield good quality powder.
- **Sauce and Chutney** : Added with spices and herbs noni pulp can be successfully exploited for preparation of sauce and chutney.
- **Toffee** : A good quality fruit toffee can be prepared by mixing noni pulp and other fruits like apple, jamun, mango, papaya, sapota, guava, fig, dates etc.

Noni fruit powder : It can be reconstituted with water and later concentrated or used as base for RTS, squash, flavoured beverages, fruit drink etc. It may contain added flavarouing substances, honey or sugar for taste modification. The powder can be used for making capsule, pills and tablets.

Noni leaves : The leaves can be powdered and exploited in preparation of herbal tea and used in capsule, pill and tablet form.

Quality requirement

1. **Hygiene.** Strive for a clean, sterile environment in the juicing area. Tools and containers may be sterilized using hot water or simple soaps and disinfectants. Personal hygiene of the juicing personnel is another important consideration.
2. **Oxygen.** Try to exclude air and oxygen for the juicing containers. The fermentation of noni juice is accomplished by an anaerobic process i.e., by bacteria that do not explicitly require oxygen for the fermentation process. However, do not enclose the fruits in the collection vessel using an air-tight seal on the vessel, because the process of fermentation leads to the evolution and accumulation of gasses within the vessel that may build up potentially explosive pressure if not released. Thus, the use of some type of fermentation

lock is recommended (i.e., a device, which allows the exit of fermentation gasses from of the container while disallowing the entry of unwanted air and airborne contaminants.

3. **Juice colour.** The colour of juice may be modified (darkened) by adding green fruits to the juice collection vessel. If green fruits are cut up before being placed into the juice collection vessel, the cut surfaces will quickly oxidize and turn brown, lending a overall brown color to the juice that drips from them. For lightest-colored juice, juice is collected or processed immediately from ripe fruits and not allowed to ferment (i.e., the juice is refrigerated or pasteurized).
4. **Filtering of sediment.** Juice may be filtered and clarified using silkscreen or paint strainers. Filters or strainers can be sterilized in boiling water before they are used.
5. **Quality control.** If juice appears overly cloudy or has an unusual or foul flavor or high pH, it is probably contaminated and should be discarded.
6. **Containers.** Avoid using plastic containers for juice collection or storage that are not food-grade plastics, as they may release undesirable chemicals into the juice.
7. **pH.** Monitoring the pH of Noni juice is highly essential. Properly aged noni juice should have a pH of 3.5 or less. If the juice pH is greater than 3.5, there is a higher probability that it may be contaminated with undesirable organisms.
8. **Labelling.** The major advertising claims about the healing powers of noni have not yet been evaluated by the Food and Drug Administration (FDA), and noni (*Morinda citrifolia*) does not yet appear on the FDA's GRAS list, i.e., the list of foods and food additives that are "Generally Recognized as Safe" by the FDA. Therefore, companies should label their product as "food supplement" and include on the label the following or similar disclaimer: "These statements have not been evaluated by the FDA. This product is not intended to diagnose, treat, cure or prevent any disease."
 - Some companies don't put nutritional information on their Noni product labels. It should be made mandatory to display nutritional information on the label.
 - Make sure the Noni juice has been pasteurized to kill off any harmful bacteria. It should say on the label that it has not been pasteurized.

9. Storage. Fresh-squeezed noni juice should be refrigerated. Aged, fermented noni juice can be stored at room temperature indefinitely.

10. Noni dosage and administration: Noni juice or juice concentrate is widely available and heavily promoted nowadays. The usual recommendation is 120 ml of noni juice 30 minutes before breakfast. For liquid concentrates, the typical recommendation is 2 tablespoons daily, and for powdered extracts, 500 to 1,000 mg daily.

11. Side effects, precautions, interactions

No major side effects have been associated with using noni. Ingestion of the juice is considered to be safe, although no toxicological studies on noni are currently known.

- Noni fruit juice contains high sugar content and should be used with caution in diabetic patients and others who need to limit their glucose and caloric intake.
- As a precaution, avoid ingesting products containing noni during pregnancy and lactation, as well as by small children, since the effects of this plant have not been studied in depth.
- Some products containing noni juice may have high amounts of potassium, which may cause hyperkalemia in susceptible individuals. As a precaution, avoid taking noni juice, containing potassium along with potassium-sparing diuretics. People with kidney problems should not take noni juice.
- Due to the purported disagreeable taste of noni fruit, some manufacturers of the noni juice also add variable amounts of other fruit juices, such as grape or orange, for example, in order to make the product more palatable. Since some of these juices may also be high in various sugars, it is advisable that diabetic patients consult with a health professional before taking this product.

Noni's bright future

Considering the positive discoveries made with noni fruit so far, there is excellent reason to anticipate that further studies will prove the fruit and its preparations beneficial to health in

numerous ways. Noni is a valuable medicinal plant. And it is likely to become an increasingly sought-after dietary supplement. Yet we have a great deal more to learn about what the plant contains and how it works. Further phytochemical investigations into noni will likely lead to the discovery of other compounds. Additional biological activity studies will provide better information about how these agents work in living organisms. At some point human clinical studies will shed additional light on the specific activities of noni in the body.

Noni, *Morinda citrifolia L.*, is a highly acceptable folk remedy, which appears to be genuinely beneficial to health in numerous ways. Stripped of hype and mumbo-jumbo, and approached with intelligence and good science, noni may prove to be one of the more diversely valuable agents in nature's medicine chest, and an enduring dietary supplement which, serves the health needs of many.

Effect of NONI (*Morinda Citrifolia L.*) on Ethylene Glycol Induced Nephrolithiasis in Rats

A. J. M. Christina*¹, Neelesh Kumar Varma¹, N. Chidambaranathan¹ N. Muruges²

Abstract

The effect of the NONI against ethylene glycol-induced nephrolithiasis in male Wistar albino rats is summarized in this study. Lithiasis was induced in rats by administering 0.75% ethylene glycol in drinking water for 28 days and was manifested by high urinary calcium, phosphate, oxalate and low urinary magnesium content. Simultaneous administration of NONI (2.5ml/kg body weight) orally for 28 days along with ethylene glycol (0.75%) reduced urinary calcium, oxalate, phosphate and elevated urinary magnesium level. It also increased the urine volume, thereby reducing the tendency for crystallization.

These observations enable us to conclude that NONI is effective against ethylene glycol-induced nephrolithiasis.

Keywords: Ethylene glycol, hyperoxaluria, NONI, nephrolithiasis, renal calculi.

Introduction

Nephrolithiasis (Renal Stone formation) is a recurrent disorder predominant in males. The present day medical management of nephrolithiasis is either costly or not without side effects. Hence, the search for antilithiatic drugs from natural sources has assumed greater importance. Many Indian plants have been quoted to be useful as antilithiatic agents. They

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are effective with fewer side effects and are also inexpensive. Hence, the Indian plants are constantly being evaluated for possible antilithiatic effects in a systematic manner. One such formulation is Noni, which is used to cure many illnesses. The traditional Indian medicine “Ayurvedha” suggests that constituents of this formulation to be antilithiatic, but scientific data supporting this statement is still lacking. Hence the present study was undertaken to assess the effect of noni on nephrolithiasis

Materials and Methods

Animals

Male albino Wistar rats (150-200 g) were obtained from Chellamuthu Trust, Madurai. They were housed in well ventilated cages (3-4/cage), maintained at $25 \pm 2^{\circ}\text{C}$ under 12 h dark/light cycle. They were fed standard pellet diet and had free access to water. The animals were maintained in these conditions for one week before the experimental session.

Plant material

The herbal formulation **NONI** supplied by Health India Laboratories, Chennai was used in this study. The formulation was diluted 10 times with water and 2.5ml/kg was administered.

Antilithiatic study

The method suggested by Selvam et al. (2001) was followed to evaluate the antilithiatic effect. The acclimatized animals were divided into 3 groups of 6 each and designated as G-1, G-II, & G-III. The animals of G-I served as the normal control. G-II animals received 0.75% ethylene glycol in drinking water *ad libitum* for 28 days and served as the lithiatic control. The G-III group animals received 0.75% ethylene glycol in drinking water *ad libitum*, along with **Noni** (2.5ml/kg body weight) by oral route for 28 days.

The 24 h urine samples were collected from rats housed in metabolic cages, on the 14th and 28th days and the volume noted. Urinary calcium (Mustafa and Medeiros, 1985), magnesium (Mustafa and Medeiros, 1985), phosphorous (Fiske and Subbarow, 1925) and oxalate (Hodgkinson and Williams, 1972) concentrations were estimated using standard methods.

Statistical analysis

The results are expressed as mean \pm SEM. Statistical analysis was carried out using one way ANOVA followed by Newman-keuls multiple range tests. Differences below $p < 0.05$ implied significance.

Results

Urinary data

The urinary output of the control and experimental rats on day 28 as follows, the urinary volume of the control rats (G-I) was 8.2 ± 0.24 ml/day/rat. In ethylene glycol treated rats (G-II), the urinary output was significantly decreased to 5.5 ± 0.28 ml/day/rat. When compared with G-II, the urinary output of the Noni group (G-III) was increased (6.4 ± 0.33 ml/day/rat), nearly to that of normal control group. The oxalate excretion has increased significantly on the 14th day in ethylene glycol treated rats (G-II) compared to the normal control rats (G-I). Maximum oxalate excretion was observed with G-II on the 28th day (2.98 ± 0.42 mg/24 h/rat). However, the oxalate excretion has reduced significantly (1.12 ± 0.14 mg/24h/rat) in the Noni treated group (G-III), though normal values were not reached. The results are presented in Table 1. Likewise, ethylene glycol treatment increased urinary calcium (4.88 ± 0.58 mg/24h/rat) and phosphate (30.18 ± 0.19 mg/24h/rat) in excretion significantly in the lithiatic control group (G-II) on the 28th day. However, after treatment with the Noni these values had reduced to 1.58 ± 0.52 mg/24h/rat and 24.25 ± 4.07 mg/24h/rat respectively in G-III. The results are presented in Tables 2 and 3.

The magnesium excretion on the 28th day has reduced following treatment with ethylene glycol in G-II (0.49 ± 0.08 mg/24h/rat). Simultaneous administration of the Noni to G-III elevated the reduced magnesium level significantly (2.89 ± 0.42 mg/24h/rat). When compared to the Lithiatic control group (G-II). The results are summarized in Table 4.

Discussion

Changes in ionic pattern of urine are the major determinant of stone formation. In this study, the ionic pattern was found disturbed by treatment with ethylene glycol. It has been

reported that daily oral administration of ethylene glycol for over 4 weeks resulted in a significant increase in oxalate excretion and that kidneys are the targets for ethylene glycol toxicity (Schlady et al., 1998). Ethylene glycol gets oxidized to oxalic acid leading to hyperoxaluria. Hyperoxaluria is reported to be a more significant risk factor in the pathogenesis of stone formation. Likewise, ethylene glycol administration increased the urinary calcium level. It has been stated that hypercalciuria favors precipitation of calcium oxalate from urine (Lemann et al., 1991). Thus, the high oxalate and calcium ion concentration in urine tends to form calcium oxalate crystals. The growth of calcium oxalate crystals is further favored by disturbances in the urinary levels of other ions like magnesium and phosphate. In this study, the high urinary phosphate level observed in ethylene glycol treated rats is likely to have formed calcium phosphate crystals.

Magnesium is a well known inhibitor of crystallization in urine. The present study also revealed a similar observation. Thus, ethylene glycol administration induces stone formation by raising urinary calcium, oxalate and phosphate and by lowering urinary magnesium as noted in G-II.

Our observations showed that Noni reduced the urinary calcium, oxalate and phosphate levels. It also raised the urinary magnesium concentration. The increase in urine volume may also minimize the tendency for crystallization. Thus, it is concluded that Noni has inhibitory potential on ethylene glycol-induced nephrolithiasis.

Table 1. Effect of Noni on oxalate excretion in experimental nephrolithiasis.

Days	G-I	G-II	G-III
14	0.65 ± 0.11	1.91 ± 0.25 ^a	0.96 ± 0.20 ^b
28	0.66 ± 0.10	2.98 ± 0.42 ^a	1.12 ± 0.14 ^b

Values are expressed as mg/24 h urine sample. Values are expressed as mean + SEM for six animals in each group.

^a values are significantly different from normal control (G-I) values on the respective days

^b values are significantly different from lithiatic control (G-II) values on the respective days.

Newman-Keuls multiple range test (P<0.05) was used.

Table 2. Effect of Noni on calcium excretion in experimental nephrolithiasis.

Days	G-I	G-II	G-III
14	0.86 ± 0.09	2.91 ± 0.30 ^a	1.75 ± 0.33
28	0.90 ± 0.13	4.88 ± 0.58 ^a	1.58 ± 0.52 ^b

Values are expressed as mg/24 h urine sample. Values are expressed as mean ± SEM for six animals in each group.

a values are significantly different from normal control (G-I) values on the respective days

b Values are significantly different from lithiatic control (G-II) values on the respective days.

Newman-Keuls multiple range test (P<0.05) was used.

Table 3. Effect of Noni on phosphate excretion in experimental nephrolithiasis.

Days	G-I	G-II	G-III
14	12.61 + 0.15	18.01 + 0.18a	15.46 + 1.38
28	12.61 ± 0.11	30.28 ± 0.19a	24.25 ± 4.07b

Values are expressed as mg/24 h urine sample. Values are expressed as mean ± SEM for six animals in each group.

a values are significantly different from normal control (G-I) values on the respective days

b values are significantly different from lithiatic control (G-II) values on the respective days.

Newman-Keuls multiple range test (P<0.05) was used.

Table 4. Effect of Noni on magnesium excretion in experimental nephrolithiasis.

Days	G-I	G-II	G-III
14	3.18 ± 0.52	0.76 ± 0.12 ^a	2.39 ± 0.47 ^b
28	3.33 ± 0.91	0.49 ± 0.08 ^a	2.89 ± 0.42 ^b

Values are expressed as mg/24 hr urine sample. Values are expressed as mean ± SEM for six animals in each group.

^avalues are significantly different from normal control (G-I) values on the respective days
^bvalues are significantly different from lithiatic control (G-II) values on the respective days.
Newman-Keuls multiple range test (P<0.05) was used.

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Scientific Validations for Therapeutic Benefits of Noni (*Morinda citrifolia. L.*)

Dr. N. Murugesh*

Abstract

Noni (Morinda citrifolia, L.) juice has been scientifically confirmed to be remarkably safe, excellently efficient and highly effective in treating and also preventing a number of diseases. It is well documented that Noni is nontoxic to blood, blood elements and also to vital organs such as liver and kidney even at very high doses. Noni has a broad range of therapeutic effects such as analgesic, anti-inflammatory, antihypertensive, immune enhancing, anticancer, antibacterial, antiviral, antifungal, antituberculous, antiprotozoal, antioxidant, anti stress and also sedative properties, Noni is effective in cough, nausea, colic, enlarged spleen, joint disorders such as gout and arthritis, senility, poor digestion, arthrosclerosis and drug addiction. These beneficial effects of Noni are strongly documented and well authenticated by valid scientific literature evidences. Also Noni has a strong cancer preventive effect. The various therapeutic benefits of Noni are due to enriched phytoconstituents. The high therapeutic profile and safety potential of Noni has a popular health enhancer and food supplement world wide.

Introduction

Morinda citrifolia., commonly called Noni, has a long history as a medicinal plant and its use as a botanical dietary supplement has grown tremendously in recent years. This has prompted a concomitant increase in research on the phytochemical constituents and biological activity of NONI (Pawlus and Kinghorn, 2007). A relatively large number of scientific publications on Noni have been published in recent years, including a number of review articles. The goal of this review is to provide an updated categorization of the phytochemical

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constituents found in noni and to provide perspective for its extensive utilization as a major botanical dietary supplement. *Morinda citrifolia* L is one of the traditional folk medicinal plants that has been used for over 2000 years. It has been reported to have a broad range of therapeutic and nutritional value (Potterat and, Hamburger 2007). The present article describes the scientifically validated therapeutic benefits of Noni

Therapeutic benefits of Noni

Noni has broad range of major therapeutic effects such as antibacterial, antiviral, anticancer, analgesic, anti-inflammatory and immune enhancing effects. It has been used effectively in abdominal pain and swelling, abscesses, back ache, chronic fatigue, sore throat and cough, diabetes, diarrhea, eye complaints, hypertension, burns, tuberculosis, heart diseases, stroke, tooth ache and intestinal worms (Wang et. al.,. 2007)

System wise therapeutic benefits

Noni is effective in treating diseases of all body systems. The various diseases related to different systems on which noni is effective are as follows.

Digestive system

Diarrhoea

Indigestion

Ulcers

Bones and joints

Arthritis

Sprain

Broken bones

Skin

Abcess, boil, blemishes

Internal disorders

Diabetes
Hypertension
Kidney and bladder

Chest

Cough
Asthma
Tuberculosis

Major phyto constituents and their uses

The major phytoconstituents present in noni and their functions and uses are as follows .

- 1. Xeronine:** It is the major and important phyto constituent of noni which is essential for most of the therapeutics benefits of Noni. Essentially it promotes cellular regeneration and hormonal balance
- 2. Scopoletin** It has anti-inflammatory and anti-microbial effects. Also it regulates sleep, hunger and body temperature
- 3. Anthraquinone:** It is a phenolic principle and it controls infectious bacteria
- 4. Damnacanthol:** It is also an anthroquinone and inhibits the growth of cancerous cells by inhibiting cell apoptosis.
- 5. Terpene:** It induces cell rejuvenation and toxin clearance.

Also present are polynutrients, selenium, amino acids and essential fatty acids which are necessary for various body functions.

Important overall characteristics (Anonymous,Web site)

The important overall characteristics of Noni which regulate body functions are :

1. Adaptogen: Balancing effect on all body systems. Noni is one of the best 12 adaptogens
2. Alkaline: Tissues degradation and disease thrives in an acidic environment. Noni juice promotes an alkaline body chemistry, the optimal state for good health.
3. Anti-oxidant: Oxidation produces DNA damage and cancer. Noni prevents this.
4. Analgesic and Anti-inflammatory: Unlike typical pain relievers and anti-inflammatories, Noni juice decreases pain and inflammation while protecting stomach, kidney, and liver cells.
5. Immunomodulator : Supports immune system, suppresses allergy and auto-immune diseases.

In order to reveal the medicinal value of Noni, the scientific evidences that support the general therapeutic claim are discussed below.

Anti-inflammatory activity, (Akihisa, et.al., 2007)

Noni is a selective COX-2 inhibitor such as celecoxib and rofecoxib. It is effective in arthritis, cellulitis, bruise, burns, ulcer and itching conditions. COX-2 inhibition is also responsible for chemo preventive effect. It also has a specific effect in gout owing to its uricosuric effect.

Antihypertensive and diuretic effect Jagetia and Baliga. (2004)

Noni lowers blood pressure. It is a potent vasodilator. Also it has an antioxidant effect and so a free radical scavenging action. It supplies nitric oxide. It has a potent diuretic effect which also contributes for antihypertensive action.

Antimicrobial effects(locher,1995)

Noni has wide range of antimicrobial effects such as antibacterial, antiviral, antifungal, antituberculous, anthelmintic and antiprotozoal effect. The bacteria sensitive to noni are *Pseudomonas aeruginosa*, *Proteus Staphylococcus*, especially normal *Bacillus subtilis*, *Escherichia coli* and *Salmonella shigella*. Antibacterial activity of Noni is due to acubin,

scopoletin, alizarin and some anthraquinones. Noni also has an antitubercular effect. It effectively kills *Mycobacterium tuberculosis*. It is equally effective as rifampicin and more possibilities need to be explored. It also has an antihelminthic effect and its effect against *Ascaris lumbricoides* (round worm) is well documented. It produces paralysis and death of this worm.

Immunological effects (palu et al.,2008)

Noni is a potent immunostimulant. It supports immune system by :

1. Stimulating the production of T cells
2. Releasing mediators like TNF-a and interleukin
3. Releasing chemokinins like interferons
4. Stimulating the function of thymus Immuno stimulating effect combats microbial and cancer growth

Antioxidant effect (Su et.al.,2005)

Noni prevents free radical induced oxidative damage and it acts by :

1. Free radical scavenging
2. Inhibiting lipid peroxidation

The antioxidant property inhibits

1. Hepatic damage caused by toxins and
2. Also prevents cancer and lung diseases in smokers

Noni as an adoptogen (Wang et.al.,2005)

Noni is an excellent adoptogen and it normalizes the functions of various body system

It helps to restore the functions of following systems :

GI tract: diarrhoea, heartburn, colitis and ulcer

Reproductive system: menstrual problems, uterine fibroids

Liver and pancreas: diabetes

Respiratory system: asthma, Sinusitis

Endocrines: Thyroid and adrenals

Cardio vascular system: heart disease and blood pressure

Nervous system: depression,sex drive, memory

Scopoletin present in Noni reduces BP and inflammation.

Noni as a nutritive (Anonymous, Website)

Noni is a nutritive booster and general tonic

Boosts general health and performance

Dramatic improvement is seen in weakened conditions

Promotes the absorption of nutrients and vitamins

Powerful antioxidant, so protects against free radical damage.

Definite increase in body weight in debilitated and devitalized conditions.

Noni treats and prevents cancer(Wang and Su 2001)

1. Noni inhibits the growth of cancer cells of breast whereas non-cancerous, normal cells not inhibited.
2. Noni is effective in lung cancer it acts by stimulating immune system. It can be combined with other chemotherapeutic agents like adriamycin, cisplatin, vincristine.
3. Noni has a cytotoxic effect in leukemia cells and hence enhances the efficacy of other anticancer drugs

Noni's mechanism in cancer.(Hirazumi et.al.,1994)

1. Xeronine, a cellular enhancer present in noni enhances and normalizes cell structure whereas cancer destroys it.
2. Noni fights cancer by activation of immune system.
3. Damnacanthol of Noni produces normal morphology and cytoskeletal structure to cancer cells by inhibiting cell apoptosis.
4. Noni produces cancer fighting substances such as Tissue Necrosis Factor and Natural Killer cells.

Anthraquinones and Alizarin present in Noni produce an adaptogenic action.

Psychological effects of Noni (Deng et.al.,2007)

Scopolectin of Noni increases serotonin levels in brain. This is effective in correcting

1. Mental depression,
2. Anxiety disorders,
3. Schizophrenia,
4. Sleep disorder,
5. Migraine and head ache,
6. Alzheimer's disease,
7. Alcohol addiction and
8. Sexual behavior.

Also Noni stimulates melatonin secretion which regulates body's physiological rhythm. Out of 111 persons treated for depression, 77 persons had decrease in symptoms in a week's time.

Benefits of Noni on cigarette smokers (Lichtenstein et.al.,2000)

Noni is effective in treating chronic cigarette smokers. It prevents them from smoking and also prevents the harmful effect of smoking. The antioxidant effect of Noni prevents

1. Free radical induced oxidative damage
2. Lipid peroxidation

This reduces cancer risk. One month double blinded clinical study on smokers has proved this fact.

Clinical Survey by Neil Solomon (Anonymous, Website)

A retrospective study by Neil Solomon reviewing the effect of noni on the results of 10,000 Noni users has revealed the following beneficial effects

67% of 847 cancer patients had lessening of symptoms

97% of patients had increased energy levels

72% over weight patients showed loss of weight
87% of hypertensives had decrease in BP
97% with chronic pain had decrease in pain
87% arthritic patients reported decrease in symptoms
80% of heart diseases-decrease in symptoms
83% of diabetics had relief in all aspects
89% reported improved digestion
85% with allergies had relief
77% with depression felt better

Safety of Noni - (Wang MY and C. Su . 2001; West et.al., 2006; and 2006a)

Noni even in large doses is safe and it does not produce toxic effect on any body system. It is devoid of allergenicity as reported by European Unions Scientific committee on food. .Also it does not produce genotoxicity as evidenced by FDA.

There is no DNA damage in vitro nor genetic damage in vivo. It has no adverse effect on body weight except normalizing the same as an adoptogen. Vital signs are not affected. There is no change in heart rate, systolic BP and diastolic BP.

Even after taking 75 ml of Noni for 4 to 6 weeks there is no effect on :

Blood elements

Blood coagulation

Renal parameters

Liver enzymes

So Noni is very safe for administration even in large doses and for prolonged periods.

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Role of Noni (*Morinda citrifolia* L.) in Spondylotic Myelopathy

Dr. Rangadhar Satapathy*

Abstract

Spondylotic myelopathy (SM) is the most common cause of spinal cord dysfunction. SM is a compression of the spinal cord in spinal region by the vertebra. In people with spondylotic myelopathy, changes in the bones, disks and ligaments of the spine cause pressure on the spinal cord. Symptoms of SM include neck stiffness, pain, numbness, weakness of the arms and legs, difficulty in walking etc. There is no fruitful treatment in SM except traction and spinal surgery. Despite advances in diagnosis and surgical treatment, many patients still have severe permanent neurological deficits caused by this condition. An improved understanding of the pathophysiology of cervical spondylotic myelopathy, particularly at a cellular and molecular level, may help to cure it completely. The pathologic course of cervical spondylotic myelopathy is characterized by early involvement of the corticospinal tracts and later destruction of anterior horn cells, demyelination of lateral and dorsolateral tracts, and relative preservation of anterior columns. Static and mechanical factors and ischemia are critical to the development of cervical spondylotic myelopathy. Free radical- and cation-mediated cell injury, glutamatergic toxicity, and apoptosis may be of relevance to the pathophysiology of cervical spondylotic myelopathy. Indian Noni - a food supplement that contains all the major and minor nutrients and also lots of phytochemicals. It helps in some way to regenerate the partially damaged neurons to its normal form by its cellular nutrients in the synergistic way. Besides that Noni contains all the antioxidant vitamins, trace minerals and lots of phytochemicals having the antioxidant properties. That's why Noni also saves the cell injury from free radicals. Lots of SM patients are getting result after using Noni.

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Introduction

Spondylotic myelopathy – an overview

Spondylosis refers to the degenerative changes that occur in the spine, including degeneration of the joints, intervertebral discs, ligaments and connective tissue of the vertebrae. There are three important pathophysiologic factors in the development of spondylotic myelopathy (SM): (1) static mechanical; (2) dynamic mechanical; and (3) spinal cord ischemia. Static mechanical factors result in the reduction of spinal canal diameter and spinal cord compression. With aging, the intervertebral discs dry out resulting in loss of disc height. This process puts greater stress on the articular cartilage of the vertebrae and their respective end plates. Osteophytic spurs develop at the margins of these end plates. Osteophytes stabilize adjacent vertebrae whose hypermobility is caused by the degeneration of the disc.

Normally, the intervertebral disc lies between the vertebral bodies, which consist of the four concentric layers.

1. the first outer layer is the 'outer annulus fibrosus'
2. the second layer below is the 'fibro cartilaginous inner annulus fibrosus'
3. the 3rd layer below is a transition zone and
4. the central portion is the 'central nucleus pulposus'

The central nucleus pulposus is a ball of transparent jelly, collagenous fibers, cells and mucopolysaccharides. The annulus fibrosus is made up of rings of fibers oriented in different directions that surround the central nucleus with a tough casing.

The discs serve as shock absorbers of the forces of compression. The ability of the nucleus to become distorted, and of the annulus fibrosus to bend, gives the vertebral bodies the ability to move on each other and to distribute the forces of compression.

Distribution of load in the intervertebral disc are in three ways as shows below : (A) In the normal, healthy disc, the nucleus distributes the load equally throughout the annulus. (B) As the disc undergoes degeneration, the nucleus loses some of its cushioning ability and transmits the load unequally to the annulus. (C) In the severely degenerated disc, the nucleus has lost all of its ability to cushion the load, which can lead to disc herniation.

As age passes or the nucleus tends to shrink and become dry, and therefore to become less elastic and more fibrous. The annulus fibrosus concomitantly thickens and becomes more prone to rupture.

So the herniation of the nuclear material occurs due to tears in the annulus fibrosus. The disc also calcifies, further stabilizing the vertebrae. Osteophytes increase the weight-bearing surface of the end plates and, therefore, decrease the effective force being placed on them. In addition to osteophytic overgrowth, the ligamentum flavum may stiffen and buckle into the spinal cord dorsally. Osteophytic overgrowth ventrally and, in some cases, buckling of the ligamentum flavum dorsally can cause direct compression of the spinal cord resulting in myelopathy (clinically evident spinal cord dysfunction). Symptoms are believed to develop when the spinal cord has been reduced by at least 30 percent.

Dynamic mechanical factors relate to the fact that the normal motion of the spine may aggravate spinal cord damage precipitated by direct mechanical static compression. During flexion, the spinal cord lengthens, thus stretching over ventral osteophytic ridges. During extension, the ligamentum flavum may buckle into the spinal cord causing a reduction of available space for the spinal cord.

Spinal cord ischemia probably plays a role in the development of SM, particularly in later stages. Histopathologic changes in the spinal cord consistent with ischemia have been observed in patients with Spondylotic myelopathy (SM).

Role of Indian Noni

1. Noni enhances the healing process of the damaged or degenerative condition of outer fibrous layer and central nucleus of Disc.

Noni is able to affect so many systems is through its ability to promote new cellular growth and to repair damaged cells

Noni fruit contains a very high concentration of proxeronine (precursor of xeronine) which are converted into xeronine when taken into the body. Proxeronine stimulates Xeronine syntheses, which in turn, enhances the healing process and removes dead tissue quickly and

safely. This explains why Noni is used in ancient times to treat burns, abrasions, cuts, wounds, and bruising. Our skin, after the liver, stores the greatest amount of proxeronine.

Xeronine is so basic to the functioning of protein, and one would die without it. Its absence can cause many kinds of illness. Xeronine alkaloid has never before been discovered because the body uses it immediately after producing it. The amount of free Xeronine left in the blood is so minute that normal chemical analytical tools are unable to detect.

Proteins need to combine with Xeronine before it can work! Protein provides most of the structure of our body right down to the cellular level. Proteins build new tissue, repair damaged tissue, and transport oxygen and nutrients into the blood.

Collagen is one of the compounds of nucleus pulposus, the connective tissue which occurs in the central portion of the disc. The fibrous layers of the disc are also composed of collagen fibers, elastic and the extracellular matrix. Collagen fibers act as the main role in the cushioning of the disc in the vertebra to external pressure load and also offer a great resistance to any pulling force. Collagen fibers are fairly simple proteins and are made up of chains of amino acids. Amino acids are delivered from circulation to the cell called fibrocytes that manufacture collagen. The three important amino acids namely glycine, hydroxyproline, and hydroxylysine are naturally present in Noni. Besides that, Noni contains 17 amino acids out of a total of 20 amino acids with all essential amino acids. Hence Noni helps in regenerating the damaged collagen in the outer fibrous layer and also the central nucleus of the disc in the case of senile degenerative conditions.

Xeronine present in Noni also tries to modify or correct the damage of fibrous layers of the disc which is made up of collagen fibers and helps to heal the damaged portion of the disc and thus prevent disc herniation.

2. Cell rejuvenating property of Noni

Noni contains all the vitamins like Vitamin A, Vitamin B complex, vitamin C, Vitamin E. It contains all the trace minerals. A number of major components have been identified in the Noni plant such as scopoletin, octoanoic acid, potassium, vitamin C, terpenoids, alkaloids, anthraquinones (such as nordanthracin, morindone, rubiadin, and rubiadin-1-methyl ether, anthraquinone glycoside), sitosterol, carotene, vitamin A, flavone glycosides, linoleic

acid, Alizarin, amino acids, acubin, *L*-asperuloside, caproic acid, caprylic acid, ursolic acid, rutin, and a putative proxeronine. All those micronutrients and xeronine which is the alkaloid of Noni has the property of rejuvenating and repairing of any damage or injured cell including nerve cells.

The many known, and even some of the unknown substances, come together in a way that supports the needs of many of our internal systems, concurrently. As the word synergy implies, these substances work far better in combination than they do separately. Many of the ingredients in Noni are found in varying amounts in other foods or herbs. There seems to be no known food or herb with either the rich list of substances or the high amounts of key substances all put together in one super food. Noni aids the body's natural healing abilities.

3. Noni also helps in reducing the clinical symptoms of pain and numbness in case of disc prolapse.

Noni is a selective COX-2 inhibitor

Pain, redness, heat, and swelling, which are the markers of inflammation, follow the release of prostaglandins. Aspirin and similar non-steroidal anti-inflammatory drugs (NSAIDs) reduce prostaglandins by blocking an enzyme which helps to produce them, called cyclooxygenase (COX). There are actually two COX enzymes in the body. They are COX-1 and COX-2. COX-1 is called the good COX enzyme, while COX-2 has earned the unflattering name as the bad enzyme. COX1 is easily identifiable and is important in regulating cell function. COX2, on the other hand, is generally undetectable in most tissues, but increases to high levels during acute inflammation. The COX2 enzyme is largely responsible for causing pain and inflammation. Injury, disease, and trauma cause COX2 enzyme to produce prostaglandins, which cause pain and inflammation. In contrast to the COX-2 enzyme, COX-1 enzyme is responsible for protecting the body's stomach lining and kidneys. COX-1 enzymes continually produce protective prostaglandins.

COX-1 is essential for blood clotting and for protecting the stomach. COX-2 is the key player in inflammation, pain, and fever. NSAIDs and other pain reducer medication deeply decrease the body's production of both enzymes, thereby decreasing inflammation while at the same time causing harm to the stomach and its lining. The ideal situation would be to find a substance that inhibited only COX-2, but did not significantly affect COX-1.

Researchers at an independent research facility found that indeed Noni was a selective inhibitor of COX-2 enzyme. In addition, the Noni did no damage to the COX1 enzyme. When scientists compared the Noni COX2 inhibition ratio of prescription pain reducer medications, they found that Noni compared “very favorably” to the prescription medications. Yet, Noni exhibited none of the negative side effects that the prescription medications are known to cause. Next, researchers compared the Noni COX2 inhibition ratio to the COX2 inhibition ratio of NSAIDs. In this category, Noni far out-performed the over-the-counter medications. And again, Noni did not exhibit any of the negative side effects associated with NSAIDs.

Noni may also help in promoting blood circulation, removing blood stasis and clearing away obstruction in the channels to relieve pain.

Noni may also help in tonifying and replenishing the liver and kidney, strengthening muscles and bones, relaxing muscles and tendons and activating collaterals.

4. Free radicals and Antioxidant property of Noni

Types of free radicals or reactive oxygen species (ROS) include the hydroxyl radical (OH.), the superoxide radical (O₂), the nitric oxide radical (NO.) and the lipid peroxy radical (LOO.). Most of the superoxide radicals are formed in the mitochondrial and microsomal electron transport chain. The hydroxyl free radicals are very reactive species and rapidly attack the macromolecules in cells. The superoxide radical, lipid hydroperoxides, and nitric oxide are comparatively less reactive. A limited number of enzymes like xanthine-oxidase, tryptophan dioxygenase, and indole-amine dioxygenase produce the superoxide free radical directly.

Free radicals or Reactive oxygen species (ROS) causes several damaging effects by attacking the lipids, proteins, enzymes, carbohydrates, and DNA of cells and tissues. They induce undesirable oxidation, causes membrane damage, protein modification, DNA damage, and cell death induced by DNA fragmentation and lipid peroxidation. This oxidative damage/stress, associated with free radicals is believed to be involved in the pathophysiological role in aging of skin and also in several diseases like heart disease (atherosclerosis), cataract, cancer, diabetic retinopathy, chronic inflammatory diseases of the gastrointestinal tract, organ dysfunction, disseminated intravascular coagulation, chronic neurodegenerative diseases.

Free radical-and cation-mediated cell injury and apoptosis may be of relevance to the pathophysiology of cervical spondylotic myelopathy

Antioxidants are believed to slow down the formation of free radicals, protecting the body by diminishing and repairing damage cells and tissues.

Antioxidant property of Noni

I. Endogenous antioxidants and role of Indian Noni

Our body has evolved with endogenous defense mechanisms to protect against free radical induced cell damage. Glutathione peroxidase, catalase, and Superoxide dismutases are three primary antioxidant enzymes in our body, which involved in direct elimination of free radicals or reactive oxygen species from our body. They require micronutrients such as selenium, iron, copper, zinc, and manganese as cofactors for their formation and optimum catalytic and effective antioxidant activity. Noni contain all the trace minerals that help for optimum catalytic activity of those three important antioxidant enzymes for an effective antioxidant defense mechanism.

Glutathione, ascorbic acid, alpha-tocopherol, beta-carotene, bilirubin, selenium, dihydrolipoic acid, melatonin etc., as a whole play a homoeostatic or protective role against Reactive Oxygen Species, (ROS) produced during normal cellular metabolism and after active oxidation insult. Noni contains all the above phyto chemicals and vitamins in abundant quantity. It also maintains ascorbate (vitamin C) and alpha-tocopherol (vitamin E), in their reduced form, which also exert an antioxidant effect by quenching free radicals. Noni stimulates to secret more melatonin from the pineal body. Thus Noni plays an active homoeostatic or proactive role against the ROS generations

Glutathione (GSH) is the most significant component that directly quenches Reactive Oxygen Species (ROS) such as lipid peroxides and plays major role in xenobiotic metabolism. Glutathione is a tripeptide made up of the amino acids gamma-glutamic acid, cysteine, and glycine. Noni contain all those glutathione making amino acids in abundant number. Thus Noni increases the body's glutathione level.

II. Exogenous antioxidants: Contribution from Noni

A number of other dietary antioxidants known as phytonutrients or phytochemicals that are being increasingly appreciated for their antioxidant activity. One example is flavonoids that are a group of polyphenolic compounds. Noni contain 150 above phytochemicals including all flavonoids. Flavonoids exhibit several biological effects such as antitumoural, anti-ischaemic, anti-allergic, anti-hepatotoxic, anti-ulcerative, and anti-inflammatory activities. These are also known to inhibit the activities of several bad enzymes like lipoxygenase, cyclooxygenase, monooxygenase, xanthine oxidizer, glutathione-S transferase, mitochondrial succino-oxidase, and protein kinases. Many of the biological activities of flavonoids are attributed to their antioxidant properties and free radical scavenging capabilities. Noni is rich with many flavonoids. Due to the inefficiency of our endogenous defense systems as well as highly exposure to environmental factors such as, cigarette smoke, air pollutants, UV radiation, and also the existence of some physiopathological situations like inflammation, ischaemia/reperfusion, the ROS are produced in excess, and therefore increasing amounts of antioxidants present in Noni will be needed for diminishing the cumulative effect of oxidative damage over an individual's life span.

Conclusion

Spondylotic myelopathy (SM) remain an important source of morbidity and suffering for the humankind. It is the most common cause of spinal cord dysfunction. Despite advances in diagnosis and surgical treatment, many patients still have severe permanent neurologic deficits caused by this condition. An improved understanding of the pathophysiology of cervical spondylotic myelopathy, particularly at a cellular and molecular level, may allow improved treatments in the future. Free radical-and cation-mediated cell injury, glutamatergic toxicity, and apoptosis may be of relevance to the pathophysiology of spondylotic myelopathy.

Noni contains all the vitamins like Vitamin A, Vitamin B complex, vitamin C, Vitamin E. It contains all the trace minerals. A number of major components have been identified in the Noni plant such as scopoletin, octoanoic acid, potassium, vitamin C, terpenoids, alkaloids, anthraquinones (such as nordamnacanthal, morindone, rubiadin, and rubiadin-1-methyl ether, anthraquinone glycoside), sitosterol, carotene, vitamin A, flavone glycosides, linoleic acid, Alizarin,

amino acids, acubin, *L*-asperuloside, caproic acid, caprylic acid, ursolic acid, rutin, and a putative proxeronine. All those micronutrients and xeronine which is the alkaloid of Noni has the property of rejuvenating and repairing of any damage or injured cell including nerve cells.

Many known, and even some of the unknown substances, come together in a way that supports the needs of many of our internal systems, concurrently. As the word synergy implies, these substances work far better in combination than they do separately. Many of the ingredients in Noni are found in varying amounts in other foods or herbs. There seems to be no known food or herb with either the rich list of substances or the high amounts of key substances all put together in one super food. Noni aids the body's natural healing abilities.

How can one combat the production of free radicals? Patients can replete their cellular and body stores with the body's most important antioxidant, glutathione and its synergistic partner antioxidants to maintain their antioxidant defense system balance through Noni that help to prevent or delay the progression of free radical related damages. Noni contains all the antioxidant vitamins such as Vitamin C, vitamin E, beta-carotene, and all antioxidant trace minerals, glutathione and lots of phytochemicals that may helps in spondylotic myelopathy. Clinical studies have proven that Noni can reduce the myelopathy sign and symptoms to great extent if used for a longer period.

Noni Clinical Trial

Indian Noni juice, the *Morinda citrifolia L.* has shown a new ray of hope in regards to the above diseases for the both preventive as well as therapeutic aspects. Herbal and natural products of folk medicine have been used for centuries in every culture throughout the world. Noni has been used as folk remedies by our ancestors for over 2000 years ago. But it was not studied or observed in a proper research way to establish its preventive and therapeutic properties in various diseases. WNRF (World Noni Research Foundation) is the first organization which has taken keen interest to conduct all research oriented work and clinical studies of this miraculous fruit *Morinda citrifolia L.* or Noni to explore its numerous health beneficiary effect for the betterment of millions of suffering peoples. It will show a ray of hope in various obstinate critical diseases which don't have any successful curative approaches in the present standard line of treatment. Noni research is the beginning of a new revolutionary

step to explore the therapeutic effect of this food supplement for the application of numerable incurable neurodegenerative diseases.

The patient named Mr. Banhu Pandit from Jamshedpur was suffering from the condition of cervical spondylotic compressive myelopathy. He had spondylitis problem last 8 years. He had severe pain on his back portion and was difficult in walking. His neurologist Dr. Sanatan Rath did his back surgery. After a few months of surgery again the complaint appeared. The walking of the patient restricted. He was not able to walk long distance and gradually the time came when it was too difficult to move in his room. He was not able to get up even from his bed. His both legs were swollen. The situation got worsened day by day. Then one fine morning he started Noni. After using of Noni for 2 months he found much improvement in his conditions. He continued it and after 6 months he was achieved great improvement in his condition. There was no pain in his back portion. There was no swelling in his both legs. He could get up from his bed comfortably and was able to walk with the support of a walker. He was feeling more energetic and active.

Role of Noni (*Morinda citrifolia* L.) in Rheumatoid Arthritis

Dr. Rangadhar Satapathy*

Abstract

Millions of men and women are affected by rheumatoid arthritis and they can be of any age. Rheumatoid arthritis can possibly trouble anybody although it affects more women than men. Rheumatoid arthritis is among the most common joint complaint among a host of individuals. It is said that rheumatoid arthritis is an autoimmune disease. By an autoimmune disease, it means the antibodies or white blood cells attack the body's own tissues. Antibodies are supposed to fight against foreign elements in the body. Yet with an autoimmune disease, they attack the body's own components by mistake. It is in fact the rheumatoid factor in the blood which directs this action of the antibodies. When there is increased rheumatoid content in the blood, irregularities in the immune system arise and so rheumatoid arthritis occurs. Rheumatoid arthritis pain can come to the point of being debilitating. As there is joint swelling and inflammation, it causes restriction in mobility. A person can be temporarily incapacitated with this disease and with a gnawing pain in the joints. Most people take the recourse of pain killers in relieving rheumatoid arthritis. There are natural remedies as well. To reduce the risk of acquiring it, one must be mindful of their bones' and body's health. For this, there should be regular exercise, a healthy diet and vitamins and mineral supplementation. These measures remain basic yet they are the pillars of good health which can ward off diseases and their discomfort. Indian Noni is a natural food supplement which contains all vitamins and all trace minerals and lots of phytochemicals and thus help in rheumatoid arthritis not only to relieve from pain and inflammation but also try to correct the after immune reaction by its immune

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modulating property. Hence Noni in case of arthritis may ward off the disease from its root level.

Introduction

Rheumatoid Arthritis – an overview

Rheumatoid arthritis (RA) causes tissues lining the joints to become swollen, stiff, and painful (inflamed). Over time, this inflammation may destroy the joint tissues. This can limit the daily activities and make it hard to walk and use hands. The exact cause of rheumatoid arthritis is not known. But rheumatoid arthritis is an auto immune disease. This means that the body's natural defense system attacks the joints. The disease also common in some families.

The symptoms : The main symptoms of rheumatoid arthritis are pain, stiffness, and swelling in the joints of the hands, wrists, elbows, feet, ankles, knees, or neck. The disease usually affects both sides of the body at the same time. In rare but severe cases, it may affect the eyes, lungs, heart, nerves, or blood vessels. Sometimes rheumatoid arthritis can cause bumps called nodules to form over the elbows, knuckles, spine, and lower leg bones.

There is no cure for rheumatoid arthritis, but treatment may help relieve symptoms and manage the disease. Treatment approach includes medicine, exercise, and lifestyle changes. There are three general classes of drugs commonly used in the treatment of rheumatoid arthritis: non-steroidal anti-inflammatory agents (NSAIDs), corticosteroids, and disease modifying anti-rheumatic drugs (DMARDs). Many of the medicines used to treat rheumatoid arthritis have side effects.

Both rest and exercise help in important ways. People with rheumatoid arthritis need a good balance between the two, with more rest when the disease is active and more exercise when it is not. Rest helps to reduce active joint inflammation and pain and to fight fatigue. Exercise is important for maintaining healthy and strong muscles, preserving joint mobility, and maintaining flexibility. Exercise can also help people sleep well, reduce pain, maintain a positive attitude, and lose weight. Exercise programs should be planned and carried out to take into account the person's physical abilities, limitations, and changing needs.

Healthy diet : An overall nutritious diet with enough but not an excess of calories, protein, and calcium is important for rheumatoid patient.

If medicine, exercise, and lifestyle changes do not help enough, surgery may be an option. Total joint replacement can be done for many joints in the body.

Role of Noni

Noni keeps the joint cartilage healthy and intact

In Rheumatoid arthritis the cartilage get damage due to the diseases progress. The damage of the cartilage also associated with dryness of synovial fluid. The Cartilage is made up of cells and intercellular matrix. The cells of cartilages are called chondrocytes. These are the actual cartilage cells that secrete the “matrix.” The intercellular matrix is the soft (relative to the bone beneath it) material that represents 95% of the cartilage. While the cells represent only a small portion of the cartilage, they must remain healthy so as to produce new matrix, when the old matrix is damaged.

In arthritis the chondrocytes get damaged due to autoimmune reaction. Hence those cartilage cells fail to secrete intercellular matrix. Noni prevents the damage of cartilage cells. The xeronine of Noni helps to repair of any damage cells including chondrocytes.

Matrix: The matrix consists of Collagen and Proteoglycans. Proteoglycans are the material surrounding the collagen fibers. It consists of a long protein molecule (the “proteo” part of proteoglycan) with strands of what are called glycosaminoglycans or GAGs, growing off its sides like the bristles on a hair brush. These GAGs (glycosaminoglycans) are heteropolysaccharides. These polysaccharides, known as the glycosaminoglycans, form a gel-like matrix and through which water, oxygen, and solutes have to go through to get to the cells. These GAG bristles allow the proteoglycan molecule to soak up water like a little sponge. It is this sponge characteristic that allows the cartilage to be soft like a mattress, yet slippery like a Slip n’ Slide when the two bones of the joint move across each other.

Noni contains polysaccharides called Noni PPT. Noni PPT is one type of muco polysaccharides like glycosaminoglycans (GAGs). Thus the arthritis patient who regularly takes Noni helps to

maintain the viscosity of matrix in proper condition with the help of Noni PPT and thus keeps the cartilage always in good condition.

Hyaluronic acid is also a major component of the joint lubricating fluid (synovial fluid). In arthritis condition the fluid get dry and makes the joint painful during movement. Noni in this case helps to increase the synovial fluid and thus makes the joint smooth for movement.

The various phytonutrients present in Noni also helps to keep the cartilage healthy and intact by inhibiting or suppressing the action of many bad proteases that causes damage to protein structures of cartilages like collagen protein and core protein of proteoglycan. The xeronine present in Noni helps to keep the collagen protein intact and healthy and also repair any damage to the core protein of proteoglycan by its protein modification property.

Over all Noni keeps the cartilage in normal and healthy condition and also repair and rebuild the damage cartilage portion in case of any arthritis.

Noni in Pain and Inflammatory conditions

Pain, redness, heat, and swelling, which are the markers of inflammation, follow the release of prostaglandins. The cell membrane is made up of phospholipids. When cell get injured the phospholipids converts to arachidonic acids. The arachidonic acids liberates prostaglandins and leukotrienes by the action of COX enzyme and 5LOX enzyme respectively. Those substances prostaglandins and leukotrienes are the potent mediator of inflammation. COX enzyme is of two types the COX 1 and COX 2. The COX2 is actually the mediator of inflammation. The COX1 has many beneficial effect in our body like protects our kidney cells and keeps our gastric mucousa healthy.

The non-steroidal anti-inflammatory drugs (NSAIDs) reduce prostaglandins by blocking cyclooxygenase (COX) enzyme as a whole. The COX2 enzyme is largely responsible for causing pain and inflammation. Injury, disease, and trauma cause COX2 enzyme to produce prostaglandins, which cause pain and inflammation. In contrast to the COX-2 enzyme, COX-1 enzyme is responsible for protecting the body's stomach lining and kidneys. COX-2 is the key player in inflammation and pain. NSAIDs decrease the body's production of both enzymes, thereby decreasing inflammation while at the same time causing harm to the stomach and

its lining. The ideal situation would be to find a substance that will inhibit to only COX-2 and LOX-5 but will not significantly affect COX-1.

Noni is a selective COX2 inhibitor as well as inhibits the 5LOX enzymes and thus block both the path of arachidonic acid inflammatory pathways. When both of COX2 and 5LOX enzymes are blocked, inflammatory leukotrienes and prostaglandins are suppressed equally and balance is achieved safely. Thus Noni reduces pain and inflammation effectively and safely.

Role of Scopoletin present in Noni in arthritis and inflammation

Another reason for pain fighting qualities of Noni may stem from several of its constituents. Noni has been shown to contain Scopoletin, which has anti inflammatory effects. Scopoletin is needed in the body for smooth joint movement. It also produces anti-histamine effects.

Conclusion

Rheumatoid arthritis, unlike osteoarthritis, is a more systemic illness. It begins with an inflammation of the synovial membrane – the source of the fluid that lubricates the bone joints. Rheumatoid arthritis is a chronic inflammatory disease that affects particularly the hands, feet, wrists, ankles, and knees, but it can also affect other organs. In the past, conventional medicine has concentrated largely on relieving the symptoms with ever larger and stronger antiinflammatory drugs. But many of these drugs cause serious side effects in some cases worse than the condition itself.

Though the cause of rheumatoid arthritis has yet to be precisely identified, there is evidence that it is related to a failure of the autoimmune system.

Different people will respond to different therapies. It is important to find someone who will not simply rely on relieving symptoms with drugs but who will be open to finding the cause of particular symptoms. It has been recorded that excellent results comes with many patients from the use of nutritional therapy combined with physical therapy and/or acupuncture.

While a nutritional approach used to be controversial—the Arthritis Foundation still insists that there is no connection between diet and arthritis—now there's overwhelming evidence pointing to diet as a major factor contributing to the development of symptoms.

Why would diet have an effect on what is essentially an autoimmune disease? Because food makes the greatest demand on the immune system. Foods contain countless allergens that the body is constantly trying to fight or adapt to. Some of these allergens are natural; others come from additives.

In this regards Indian Noni is a natural fruit juice concentration that contain all the major and micro nutrients those help in many way to rheumatoid arthritis patient. The patients who are using Noni are getting very good results.

Noni Clinical Trial

The patient named Ramesh swahar from Berhampur, state orissa was suffering from Rheumatoid Arthritis with spondylitis last 4 years. He was taking pain killers for his arthritis complaint but was getting temporarily relieved from his joints pain. Due to spondylitis his back was paining a lot and was difficult in walking. His neurologist advised him to go for the operation and he did it. But after few months of operation his condition got worse than before. He felt severe back ache and was not able to walk. A time came when he was completely bedridden. His all joints were paining and there was oedematic swelling of his both legs. He started Noni for his complaint. After 2 months of use of Noni his all swellings got disappeared and pain got reduced than before. Back ache also got reduced than before and he was able to sit and walk with the help of walker. After 6 months use of Noni he was walking comfortably with the help of a stick only. There was no pain on his back portion and joints. There was no swelling of his both legs. His finger's deformities due to rheumatoid arthritis effect was also got improved. He was feeling energetic and his hemoglobin percentage raised from 8 % to 12 %.

Effects of Noni (*Morinda citrifolia L.*) on Carcinoma of Breast

Dr. Rangadhar Satapathy*

Abstract

Breast cancer is the fifth most common cause of cancer death (after lung cancer, stomach cancer, liver cancer, and colon cancer). In 2005, breast cancer caused 502,000 deaths (7% of cancer deaths; almost 1% of all deaths) worldwide. Among women, breast cancer is the most common cause of cancer death. The mainstay of breast cancer treatment is surgery when the tumor is localized, with possible adjuvant chemotherapy, and/or radiotherapy. Depending on clinical criteria (age, type of cancer, size, metastasis) patients are roughly divided in to high risk and low risk cases, with each risk category following different rules for therapy. Treatment possibilities include radiation therapy, chemotherapy, hormone therapy, and immune therapy. Nothing guarantees that one won't develop breast cancer. There are lots of side effects of chemotherapy and radiotherapy that makes the patient worse than cancer itself. Indian Noni help to overcome maximum side effects of all cancer cases including the breast cancer by its immune enhancing and nutritive supplementing property. It also contains many bio anti carcinogenic ingredients that helps by enhancing the efficacy of the cancer treatment too. It act as a tool for primary prevention, secondary prevention and as an adjuvant immune enhancing supplement with the common line of cancer treatment.

Introduction

Breast Cancer – An overview

Breast cancer, the second-leading cause of cancer deaths in India, is the disease women fear most. Breast cancer can also occur in men. Today, radical mastectomy is rarely performed.

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Most breast lumps are not cancerous. Yet the most common sign of breast cancer for both men and women is a lump or thickening in the breast. Often, the lump is painless. In breast cancer, some of the cells in the breast begin growing abnormally. These cells divide more rapidly than healthy cells do and may spread (metastasize) through the breast, to the lymph nodes or to other parts of the body. The most common type of breast cancer begins in the milk-producing ducts, but cancer may also begin in the lobules or in other breast tissue. In most cases, it is not clear what causes normal breast cells to become cancerous. Doctors do know that only 5 to 10 percent of breast cancer is inherited. Treatments exist for every type and stage of breast cancer. Most women will have surgery and an additional (adjuvant) therapy such as radiation, chemotherapy or hormone therapy.

Because breast cancer treatment is likely to damage healthy cells and tissues, unwanted side effects are common. Specific breast cancer side effects depend mainly on the type and extent of the treatment. Side effects of breast cancer radiation therapy – including uncommon side effects that may involve the heart, lungs, and ribs. One of the common side effects of breast cancer radiation treatment is fatigue, especially in the later weeks of treatment and for sometime afterward. The side effects of chemotherapy depend mainly on the drugs the patient receives. As with other types of breast cancer treatment, side effects vary from person to person. In general, anticancer drugs affect rapidly dividing cells. These include blood cells, which fight infection, cause the blood to clot, and carry oxygen to all parts of the body. When blood cells are affected by anticancer drugs, patients are more likely to get infections, bruise or bleed easily, and may have less energy during treatment and for some time afterward. Cells in hair follicles and cells that line the digestive tract also divide rapidly. As a result of chemotherapy, patients may lose their hair and may have other side effects, such as loss of appetite, nausea, vomiting, diarrhea, or mouth sores.

Indian Noni and Cancer

Noni ppt (The polysaccharide)

Noni has anti tumor activity by stimulating immune factors like TNE, NK cells etc. to attack the tumor.

Noni ppt (The polysaccharide) is one unique polysaccharide that can be used as a chemo-
immunotherapy agent to treat cancer. NONI-ppt present in NONI develop//////////s an anti-
tumor response by stimulating the release of various cytokines mediator of the immune
system of our body like

- Interleukin
- Interferon – gamma
- Nitric oxide
- Tumour necrosis factor
- Natural killer cells

Thus they help in controlling carcinogenesis by inhibiting the growth and mutation of the
malignant cells

Pretreatment with Noni followed by ultraviolet irradiation increased the levels of
phosphorylated extra cellular signal-regulated kinases (ERK) and stress-activated protein
kinases (SAPK) enzymes in the body. Activation of SARK and ERKs plays an important role in
triggering apoptosis. Thus their activation proves the stimulatory effect of Noni on ultraviolet-
induced apoptosis. Thus Noni can be used as an immune supplemental therapeutic agent
with any cancer therapy.

Noni exhibits anti angiogenesis effects on the malignant cells.

The cancer tumor has the ability to develop its own blood vessels around it to get their
nutrition for growth by the process of angiogenesis. About 150+ phytochemicals present in
Noni like Damnacanthal, Alcerin, limonene, Epigallocatechin gallate (EGCg) etc, to name a
few, exhibit antiangiogenesis effect on the malignant cells thus inhibiting the growth and
mutations of these cells and induces program cell death or apoptosis..

Epigallocatechin gallate (EGCg)- EGCg is a polyphenolic flavonoid antioxidant that is found
in abundance in Noni. EGCg in Noni inhibits the quinol oxidase (NOX) enzyme including
tumor activity, thus helping in antiangiogenesis.

NOX enzymes are found in a variety of cell types and tissues where they react with oxygen to
generate reactive oxygen species (ROS), the free radical forms of oxygen that damage the
DNA of cell.

The ROS is involved in mutations and tissue damage in diseases such as cancer and rheumatoid arthritis. Normal amounts of NOX production are important to regulate the cell growth. It is generally inactive during the normal cell division process, in response to growth hormone stimulation but it is active in cancerous cells and responsible for the cancerous cell proliferation, cell motility, invasion and angiogenesis process, all of which are prerequisites for tumor metastasis.

EGCg, a primary component of NONI inhibits the NOX activity of cancer cells. According to DR.Morre's experimental studies it is found that EGCg in NONI inhibits NOX carcinogenesis activity but does not inhibit the NOX activity of healthy cells.

Noni prevents the carcinogen DNA adduct formation on cell

Noni Prevents DNA adduct formation, and hence protects the cell from converting to cancer. Hence Noni can be used for primary and secondary prevention of cancer. Most chemical carcinogens binds to our genetic DNA to form DNA adducts. Carcinogen DNA adducts formation causes DNA damage. Carcinogen DNA adducts can be repaired by body enzymes. The unprepared DNA damaged cell will be responsible for mutation and consequent cancer development. Therefore preventing carcinogen-DNA adduct formation is a key step for primary prevention in cancer at the initiation of carcinogenesis.

Noni helps to check the carcinogen DNA adduct formation. Hence it may prevent cancer at the initiation stage of carcinogenesis.

Role of Antioxidant in Cancer Prevention

Oxidative stress in our body is the underlying cause of cancer. When excessive free radicals are allowed to exist near the nucleus of cell, significant damage to the DNA of cell can result. Free radicals can also wreck damage on the genetic structure of the DNA, which can then lead to abnormal growth of cell. As these cells continue to replicate, this mutated DNA is carried to each newly developed cell. When there is further oxidative stress to this mutated DNA of the cell, more damage occurs. The cell will then begin to grow out of control. It spreads from one part of the body to other (metastasis), thus becoming a true cancer.

Oxidative stress is indeed the cause of cancer and antioxidants used to bring free radical back into balance would lower the risk of cancer. Therefore, the bet strategy is to maximize body's immune system and antioxidant defense and this begins by eating a healthy natural supplement that rich with antioxidants. **Noni is the rich source of antioxidants.** The high anti oxidant property of Noni helps to prevent the formation of carcinogen-DNA adducts. It was hypothesized that the antioxidants in Noni may have cancer protective effects by scavenging reactive oxygen free radicals and quenching lipid peroxides. In vitro study shows that the Damnanthal, one phytochemical present in Noni have anti-carcinogenic effect.

Glutathione S-transferase (GST)

The Glutathione S-transferase (GST) is a system which eliminates carcinogens. Limonene, present in Noni juice seems to promote the GST system in the liver and small bowel, thereby decreasing the damaging effects of carcinogens. Animal studies demonstrated that dietary limonene present in Noni reduced mammary tumour growth.

Noni inhibits Matrix metalloproteinases (MMPs) enzyme

Matrix metalloproteinases (MMPs), the enzyme have been identified as key players in tumor invasion and metastasis. Excessive MMPs secretion has been regarded as an index of malignancy which leads to the degradation of extra cellular matrix. Lysine and proline are building blocks of collagen fibers that stabilize connective tissue by inhibiting the enzymatic digestion of collagen fibers. Vitamin C is essential for production of collagen and acts as a powerful antioxidant by scavenging free radicals and thereby protects cells from damage. Epigallocatechin gallate (EGCG) has antioxidant and anticancerogenic properties. It prevent cancer cell invasion by inhibiting MMPs. The natural amino acid lysine, especially in combination with vitamin C and other selected cellular nutrients, is capable of blocking this 'collagen digestion'. Noni contains the above two amino acids lysine and praline. Noni is rich with vitamin C. Noni contain the phytochemicals Epigallocatechin gallate (EGCG). Hence Noni should help to prevent the cancer tumor invasion and metastasis.

Limonene, the phytochemicals present in Noni increases the levels of liver enzymes involved in detoxifying carcinogens.

Many recent studies have shown that elevation of phase II enzymes, such as NAD(P) H : quinone reductase (QR) and GST, correlates with protection against chemical - induced carcinogenesis in animal models, in the stage of promotion as well as initiation. Noni fruits contain an extremely potent quinone reductase inducer, 2 - methoxy - 1,6 - trihydroxyanthraquinone. This new anthraquinone was nearly 40 times more potent than any other quinone.

Noni contain many glycosides -

Noni contain many glycosides. Asperuloside is a glycoside. Traditionally, this glycoside has been used for diuresis. Research has indicated that it is also an anticlastogenic (that is, prevents the breakage of chromosomes). As a result, it is anti-mutagenic or resists mutation within the cell's DNA.

Three new glycosides were isolated from *Morinda citrifolia* (Noni) fruit. They are;

1. 6-O- (beta-D-glucopyranosyl) -1-O-octanoyl-beta-D-glucopyranose,
2. 2,6-O- (beta-D-glucopyranosyl) -1-O-hexanoyl-beta-D-glucopyranose,
3. 3-methylbut-3-enyl-6-O-beta-D-glucopyranosyl-beta-D-glucopyranoside.

Conclusion

Current treatment protocols with chemotherapy and / or radiation although beneficial, are toxic and have the potential to destroy healthy cells as well. Our approach has been to develop strategies to inhibit cancer development, progression and metastasis using naturally occurring nutrients, which are relatively non-toxic. Indian Noni is one among them. It contains all the major and most micro nutrients. Noni is helpful for cancer patient. Along with all the cancer treatment if Noni is added with their treatment protocol it will cover maximum side effects of chemotherapy or radio therapy; acts as an immune supplemental adjuvant to the current therapy; as it prevents the DNA adduct formation it help in primary prevention and secondary prevention for all cancer patient or those with family history of cancer treatment.

Noni Clinical Trial

The patient named Mrs. Lalita Pahan from Berhampur, Orissa was suffering from carcinoma of breast. Her condition was pretty worse before four months. The whole right breast and axillary portion had severe swelling with radiating pain from breast to axial and back. There was a big nodular hard mass inside the right breast. Her treating physician sent her for the FNAC report of that portion and it was detected cancer of breast. She was advised for the operation as the cancer had already spread to the axillary lymph nodes. Due to scarcity of money she did not go for operation. Then she started consuming Noni three months back. After taking Noni for three months her hard nodular mass softened and gradually reduced in size. The surrounding swellings of the mammary gland gradually improved. The pain reduced a lot. Since one month that portion is bleeds sometimes. Now the condition has improved more than 70 % than before. She is now continuing Noni internally as well as applying Noni externally.

Effect of Noni on Filarial Worm Infestation – In Vitro Study

Dr. Rangadhar Satapathy*

Abstract

Lymphatic Filariasis is a parasitic and infectious tropical disease, caused by the thread-like parasitic filarial worms, Wuchereria bancrofti, Brugia malayi, and Brugia timori, all transmitted by mosquitoes. The most spectacular symptom of lymphatic filariasis is elephantiasis (thickening of the skin and underlying tissues), which was the first disease discovered to be transmitted by insects. Elephantiasis is caused when the parasites lodge in the lymphatic system. Elephantiasis affects mainly the lower extremities, whereas ears, mucus membranes, and amputation stumps are rarely affected; however, it depends on the species of filaria. W. bancrofti can affect the legs, arms, vulva, breasts, while Brugia timori rarely affects the genitals.

One vitro study showed that the adult parasite of Wuchereria bancrofti died within 20 hours in the culture media mixed with Noni in comparison to the control group which survived for 60 hours without adding Noni. Similarly extract of Noni induces paralysis and death of the human parasitic nematode worm, Ascaris Lumbricoides, within a day.

Hence it can be suggested to prescribe Noni along with other medication of the filariasis.

Introduction

It has been shown that Noni has anti helminthic effect on Round worm (*Ascaris Lumbricoids*). Noni has been used in the Philippines and Hawaii as an effective anti-parasitic. On that basis an invitro study of the effects of Noni juice on both adult and microfilaria of cattle

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parasite *Setaria digitata* has been conducted. Lymphatic Filariasis is a parasitic and infectious tropical disease, caused by three thread-like parasitic filarial worms, *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*, all transmitted by mosquitoes

The signs and symptoms: lymph adenoma, massive leg swelling, elephantiasis, lymphangitis, fever, pain epididymitis, orchitis, eosinophilia, etc.

Objectives

To evaluate the effect of Noni on different stages of filarial parasites

Materials And Methods

1. Collection of *Setaria digitata*: Adult female *Setaria digitata*, cattle filarial parasites were collected from the local slaughter house.

2. Collection of *Microfilaria*: Adult parasites were cut into different pieces in the ISCOV medium and kept at 37degree centigrade for 1 hour. *Microfilaria* were harvested after centrifuging at 10'000 RPM

Microfilaria count was then adjusted to 2000 mf /1 ml of medium.

100 micron medium = 200 mf +Noni

Medium:

Adult *Setaria digitata* parasites were incubated at 37degree centigrade in ISCOV medium at antibiotic and antimycotic care with 10% FCS (Foetal calf serum) at 5% CO₂.

Different Noni Dilutions

Two dilutions of Noni were prepared –

1. N: 50 (i.e. one part Noni with 50 parts of medium)

2. N: 25 (i.e. one part Noni with 25 part medium). Both the Noni dilutions were filtered through 25 micron filter before adding to the culture medium.

Control group of parasites were cultured in the medium without Noni that is named C

Effects of Noni on Adult Parasite - An In Vitro Study

Medium and Groups

3 groups were prepared

1. Control group C (no dilution of Noni)
2. Group 1 (where N: 50 Noni dilutions were added with the culture medium).
3. Group 2 (where N: 25 Noni dilutions were added with the culture medium).

4 adult parasites were taken in each group

Observations

The motility of the adult parasites was noted at day 1, 2, and 3.

It was found that –

At day1 the motility was almost same in each group

At day 2 (after 24 hrs) the motility of Gr-1 and Gr-2 were sluggish than control.

At day 3 (after 48 hrs) some parasite of Gr-1 and Gr-2 were dead and the rest of them were moving very slowly

Effects of Noni on Microfilaria - An In Vitro Study

Medium and Group - Same ISCOV medium

Same 3 groups were prepared

1. Control group C (no dilution of Noni).
2. Group 1 (where N: 50 Noni dilutions were added with the culture medium).
3. Group 2 (where N: 25 Noni dilutions were added with the culture medium).

About 200 microfilaria were taken in each group.

Observations

The motility of the microfilaria were noted at day 1, 2, 3 & 4.

It was found that –

At day1 the motility was almost same in each group

At day 2 (after 24 hrs) the motility of Gr-1 and Gr-2 were sluggish than control. Gr-2 motility was more sluggish than Gr-1

At day 3 (after 48 hrs) the motility of Gr-1 was remarkably sluggish and Gr-2 were found dead without any movement.

At day 4 (after 72 hrs) the microfilaria in both the Gr-1 and Gr-2 were found dead without any movement.

Conclusion

From this study it is concluded that Noni induces neuromuscular effects (paralysis) and death of the filarial parasite both in adult and microfilaria at a higher concentrations within 48 hours.

Studies of Comparative Anti-HIV Activity and cytotoxicity of *Morinda citrifolia* L.

Periyasamy Selvam*¹, Narayanan Muruges², Myriam Witvrouw³

Abstract

Fruit juice and ethanol, methanolic extract of fruit powder of Morinda citrifolia (MC) have been studied against the replication of HIV-1 (III_B) in MT-4 cells. Fruit juice of Morinda citrifolia (MC) exhibited a maximum protection of 18% of the cells against the cytopathic effect of HIV-1 (III_B) strain and displayed marked cytotoxic activity in lymphocyte (MT-4) cells (CC₅₀: 0.19 mg/ml). However the ethanol (EMC) and methanol extracts (MMC) displayed cytotoxic activity (CC₅₀) in lymphocyte (MT-4) cells only at higher concentration the CC₅₀ being at 72.34 and 220 µg/ml respectively.

Keywords : Morinda citrifolia, Anti-HIV activity, MT-4 Cell, Cytostatic

Introduction

Acquired immunodeficiency syndrome (AIDS) is a life threatening and debilitating disease caused by retrovirus infection, and the etiologic agent is now widely known as the human immunodeficiency virus type 1. Many compounds of plant origin have been identified that inhibit different stages in the replication cycle of HIV (Wu., *et. al.* 2004; Sanchez *et. al.*, 2001; Shahidul *et. al.* 2000, Hu *et al.*, 2000). *Morinda citrifolia* L (Noni) has been used in folk remedies by Polynesians for over 2000 years, and is reported to have a broad range of therapeutic effects, including antibacterial, antiviral, antifungal, antitumor, antihelminth,

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analgesic, hypotensive, anti-inflammatory, and immune enhancing effects (Wang MY *et. al.* 2002). The present study is designed to determine the antiviral activity of fruit juice and ethanol (EMC) and methanol (MMC) extract of *Morinda citrifolia* (MC) against the replication of HIV-1 (III_B) in MT-4 cells and Cytotoxicity in mock-infected MT-4 cells was also assessed by the MTT method.

Material and Methods

Extraction: Fruit juice of *Morinda citrifolia*, a gift from Health India laboratory, Chennai, Tamilnadu, India. The fruit powder of *Morinda citrifolia* was subjected to hot continuous percolation using methanol and ethanol. The methanol (MMC) and ethanol (EMC) extracts of *Morinda citrifolia* were concentrated by distillation and used for screening.

Anti-HIV Assay : *Morinda citrifolia* was tested for its inhibitory effects against the replication of HIV-1 (III_B) in MT-4 cells (Pauwels *et. al.*, 1988 and Witvrouw *et. al.*, 2004). The MT-4 cells were grown and maintained in RPMI 1640 DM Medium supplemented with 10% (v/v) heat-inactivated Fetal Calf Serum (FCS), 2 mM-glutamine, 0.1% Sodium bicarbonate and 20mg/ml gentamicin (culture medium). Inhibitory effect of *Morinda citrifolia* on HIV-1 replication was monitored by inhibition of virus-induced cytopathic effect in MT-4 cells and were estimated by MTT assay. Briefly, 50 ml of HIV-1 and HIV-2 (100-300 CCID₅₀) were added to a flat-bottomed microtiter tray with 50 ml of medium containing various concentrations of extracts of MCT. MT-4 cells were added at a final concentration of 6x10⁵ cells/ml. After 5 days of incubation at 37°C, the number of viable cells were determined by the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) method. Cytotoxicity of *Morinda citrifolia* against mock-infected MT-4 cells was also assessed by the MTT method. The anti-HIV data are presented in Table 1.

Results and Discussion

An ethanolic, methnolic extract and fruit juice of *Morinda citrifolia* has been evaluated for its anti-HIV activity and cytotoxicity (Table 1) against HIV-1 (III_B) replication in acutely infected MT-4 cells. *Morinda citrifolia* exhibited a maximum protection of 18% of the MT-4 cells against the cytopathic effect of HIV-1 (III_B) after acute infection. *Morinda citrifolia* displayed

marked cytotoxic activity in lymphocyte (MT-4) cells (CC_{50} : 0.19 mg/ml). Both ethanol (EMC) and methanol extracts (MMC) displayed cytotoxic activity (CC_{50}) in lymphocyte (MT-4) cells at 72.34 and 220 μ g/ml respectively.

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Table1. Anti-HIV (III_B) Activity and Cytotoxicity of *Morinda citrifolia* in MT-4 cells

Compound	EC ₅₀ ^a (µg/ml)	CC ₅₀ ^b (µg/ml)	Maximum % Protection
MC	>0.19	0.19	18
EMC	>72.34	72.34	0
MMC	>220	220	0
AZT (STD)	0.0062	65.65	106

^a Concentration required to inhibit the cytopathic effect of HIV-1 (III_B) in MT-4 cells by 50%.

^b Concentration required to cause cytotoxicity to 50% of the MT-4 cells.

Cytotoxicity in Human Retinoblastoma Y79 cells by the fruit extract of Noni (*Morinda citrifolia* L.)

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Abstract

Morinda citrifolia L. an evergreen tropical tree species is used traditionally to treat several human ailments in many Asian countries and Pacific Islands. Recent reports have indicated that Noni fruit extract is effective against cancer, diabetes, burn injuries, ulcer, etc. However, not much work has been done in India in spite of its abundant availability. Although the antitumor and anticancer activities of Noni have already been demonstrated, no report is available yet on the effect of Noni on retinoblastoma (RB), the common primary intraocular tumor in children. With this background, the present study was aimed to investigate the activity of *M. citrifolia* L. fruit extract against the retinoblastoma, the childhood eye cancer. Treatment with ethanolic fruit extract of *M. citrifolia* L induced apoptosis in Y79 cells as characterized by microscopic evidences of cell shrinkage, membrane blebbing and granule formation. The cytotoxic effect was confirmed by MTT based cell viability assay, which was concentration dependent. The apoptotic cells initiated DNA fragmentation, as examined by agarose gel electrophoresis. The results revealed that the fruit extract of Noni has excellent cytotoxic effect.

Keywords : *Morinda citrifolia*, retinoblastoma, cytotoxicity, apoptosis, DNA fragmentation.

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Introduction

Morinda citrifolia L., popularly known as Noni, is distributed worldwide mostly in the coastal regions. The fruit of *M. citrifolia* has been used by the Polynesians in a variety of medicinal preparations and as a famine food (Wang et al, 2002; Mathivanan et al, 2005). *M. citrifolia* belongs to the family Rubiaceae has several common names, viz. Indian mulberry, Nuna, cheese fruit, mengkudu, etc. and it is also known as Pain killer bush, head ache tree due to its medicinal properties (Morton, 1992; Nelson, 2001; Ross, 2001; Wang et al, 2002). The fruit is widely used for the extraction of juice as health tonic, which has been exploited commercially in recent times. The juice has been recently accepted by the European Union as a novel food. Not only the fruit even the leaves, bark and root of *M. citrifolia* have been commercially exploited for the preparation of red dye, facial creams, soaps, lotion, tea powder, etc. There are more than 19 patents on Noni have already been registered in the US Patent and Trade Mark Office since 1976. Our Indian ancestors have very well aware the medicinal properties of *Morinda* spp. and they used them in their traditional systems of medicine such as Siddha and Auyurveda.

In recent years scientists focused on the nutritive and therapeutic properties of Noni resulted in a large number of products available in the market. Noni has been promoted to treat a vast array of diseases ranging from cancer to sexual dysfunction. The indigenous tribes of Australia use the ripe fruits of *M. citrifolia* for treatment of respiratory infections. Recent scientific studies demonstrate the pharmacological properties of *M. citrifolia*. The ethanol extracts from the aerial parts of *M. citrifolia* have antibacterial and analgesic activity and the root and fruit extracts have hypotensive and analgesic effect (Wang et al, 2002).

It has been demonstrated that juice from *M. citrifolia* is effective in inhibiting new angiogenic growth in human placental vein explants (Hornick, et al., 2003); reducing the rate of capillary proliferation and the development of vascular networks in vein discs in which angiogenesis does occur; inducing apoptosis in newly formed angiogenic networks and suppressing both angiogenic incidence and vessel development in human breast cancer explants. But no report is available yet on the effect of Noni on retinoblastoma, the common primary intraocular tumor in children (). The incidence of RB is higher in the lesser-industrialized countries and in less affluent populations. (Stiller, et al., 1996; Finger, et al., 2002; Biswas, et al., 2003).

Angiogenesis plays an important role in tumor invasion and survival. Critical steps during tumor angiogenesis are the outgrowth of endothelial cells from pre-existing capillary vessels initiated by the migration of endothelial cells away from the parental vessels. Endothelial cells proliferate in response to vascular endothelial growth factor (VEGF). Proliferating endothelial cells subsequently remodel the extracellular matrix around neovasculature sites, align into tube-like structures, and eventually form new functional blood vessels. Extracellular matrix remodeling occurs continuously throughout the tumor angiogenic process in a well-orchestrated fashion involving numerous extracellular matrix-degrading enzymes. Among them, matrix metalloproteinases (MMPs) are believed to be a critical group of enzymes that affect tumor angiogenesis, tumor growth, local invasion, and subsequent distant metastasis² (Moses, 1997; Nelson et al., 2000). In addition, VEGF is being influenced by the NOS enzymes in the tumor environment through the depletion of intracellular iron; the expression of VEGF is activated. NOS2 is known to function as an up-regulator of VEGF-regulated kinases and mitogen-activated protein kinases. Thus, novel therapies have emerged that use this phenomenon as a target for cancer therapies. To date, more than three dozen clinical trials have been approved that target tumor angiogenic and antiangiogenic factors. However, herbal drugs and their potential in antitumorigenic and antiangiogenic properties have not been much explored which have got less toxicity and less morbidity to the cancer patients. With this background the present study investigates the *M. citrifolia* induced cytotoxicity in retinoblastoma Y79 cells.

Materials and methods

Cell line

The retinoblastoma Y79 cell line (Fig. 1) was obtained from American Type Cell Culture collection. It is derived from the primary tumor in the right eye of two years-old Caucasian girl. It is maintained in RPMI 1640 medium with 2 mM L-glutamine, 10 mM HEPES, 1 mM sodium pyruvate, 4.5 g/L glucose, 1.5 g/L bicarbonate supplemented with 15 % FBS (Albert et al., 1970).

Preparation of *M. citrifolia* fruit extract

M. citrifolia tree was identified using the keys of The Flora of Madras Presidency (Gamble

and Fisher, 1976). The ripen fruits were collected from the trees located in the coast of Kasargod, Kerala, India. They were washed thoroughly with distilled water, cut into small pieces, air dried and ground using pestle and mortar. Coarsely powdered fruit material was extracted with ethanol for 48 h and filtered through Whatman No. 1 filter paper. The filtrate was dried in an oven at 40°C for 3 days and the concentrated extract was used for further studies.

***In vitro* cytotoxicity activity of *M. citrifolia* fruit extract on Y79 cell line**

The MTT method, described by Hussain et al., (1993), is a quantitative colorimetric assay capable of detecting living but not dead cells. In this method, a tetrazolium salt is reduced by mitochondrial dehydrogenases to a purple formazon. In brief approximately 5x10³ cells/well was seeded onto 96 wells plate (Fig. 2), 100 µl of RPMI 1640 medium was added and incubated at 37°C for 24 h. After 24 h, medium was discarded and fresh medium was added with different concentrations of *M. citrifolia* fruit extract and incubated for 1-4 days. After respective incubation period, medium was discarded and 100 µl fresh medium was added with 10 µl of MTT (5 mg/ml) and incubated at 37°C in a CO₂ incubator. After 4 h, medium was discarded and 100 µl of DMSO was added to dissolve the formazon crystals. Reading was taken spectrophotometrically at 570 nm. Cell survival was calculated by the following equation.

$$\text{Viable cell \%} = \frac{\text{Test OD}}{\text{Control OD}} \times 100$$

Assessment of apoptosis

The cells were monitored under microscope, without fixation to assess the morphological changes (apoptosis) induced by the treatment of *M. citrifolia* alcoholic fruit extract, under the condition of normal illumination using inverted microscope (Vento et al., 1998).

DNA fragmentation assay

After incubation with *M. citrifolia* fruit extract, the Y79 cells were processed for DNA fragmentation analysis by agarose gel electrophoresis as described by Hermann et al. (1994). The treated Y79 cells were washed twice with PBS and DNA extraction was performed using Quick Genomic DNA Extraction Kit according to the manufacturer instructions. The DNA

pellet was resuspended in TE buffer (10 mmol/L Tris-HCl, 1 mmol/L EDTA, pH 8.0) prior to loading (10 μ l) on to a 1.5% agarose gel containing 0.5 μ g/ml ethidium bromide. Electrophoresis was conducted at 35 V for 4 h. DNA fragments were visualized and photographed under UV illumination. DNA marker was used to estimate the size of DNA fragment.

Results and discussion

In the present work it was demonstrated the *M. citrifolia* L. fruit extract induced apoptosis in Y79 cells. This conclusion was suggested by morphological modifications evidenced after treatment with fruit extract, and was confirmed by DNA fragmentation assay.

***In vitro* cytotoxicity activity of *M. citrifolia* fruit extract of on Y79 cell line**

The crude fruit extract of *M. citrifolia* reduced the Y79 cell viability as determined by MTT based dye reduction method, which measured mitochondrial respiratory function and detected the onset of cell death. It was found from the study that the crude fruit extract reduced the viability of cells to 50 % (IC₅₀) at 800 μ g/ml, on incubation for 72 h at 37°C in CO₂ incubator. Loss of viability was first observed at 500 μ g/ml (68% at 48 h and 67% at 72 h). Significant loss of cells was observed at 600 – 800 μ g/ml (46% at 72 h and 49% at 96 h), after which the Y79 cells degenerated progressively. It was inferred from the study that the loss of cell viability was time and dose dependent manner, which supported the previous study of Vento et al. (1998), where similar result was obtained when the retinoblastoma Y79 cells incubated with different time period with C2-ceramide.

Effect of fruit extract of *M. citrifolia* on apoptotic morphology in Y79 cells

Light microscopy examination of Y79 cells after treatment with fruit extract of *M. citrifolia* for 48 h showed prominent apoptotic morphology as shown in Fig. 3. The treatment of fruit extract induced cell shrinkage, membrane blebbing and membranous apoptotic bodies as described earlier by Vento et al., 1998.

DNA internucleosomal fragmentation

It was observed that the apoptotic morphology induced by the fruit extract of *M. citrifolia* was accompanied by DNA fragmentation. Fruit extract of *M. citrifolia* induced the appearance

of DNA ladder of apoptotic cell death. The evidence of fragmentation started at the concentration of 300 µg/ml and the progressive DNA ladder was observed at 400 µg/ml. It is well known that the internucleosomal DNA fragmentation responsible for DNA ladder is usually maintained to be peculiar to apoptosis (Gerschenson and Rotello, 1992). Depending on the cell type, the same drug can either suppress or stimulate apoptosis, and in the same cell types DNA fragmentation can accompany or not apoptosis, depending on the drug employed (Falcieri et al., 1993). Our study clearly indicated the fragmentation of Y79 cells as induced by the fruit extract from *M. citrifolia*, stimulated apoptosis.

Conclusion

M. citrifolia L. fruit extract showed good cytotoxicity against retinoblastoma Y79 cells and it was prominent at higher concentration. The apoptosis induced by the fruit extract is accompanied by prominent DNA fragmentation, a characteristic feature for cell apoptosis.

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About the Editor

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Dr. Rethinam is a great academician, Researcher and Research Coordinator and Administrator. He started his career as Research Assistant and then Assistant Professor and later selected for All India Agricultural Research Service in 1976.

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