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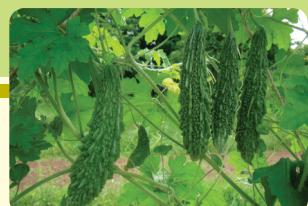
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National Seminar-cum-Workshop on STRATEGIES FOR IMPROVEMENT, ENHANCING PRODUCTIVITY AND UTILIZATION OF CUCURBITS

August 8-10, 2014

SOUVENIR &
BOOK OF ABSTRACTS



Organized jointly by
SOCIETY FOR PROMOTION OF HORTICULTURE
IIHR, Bengaluru
&
CENTRAL HORTICULTURAL EXPERIMENT STATION
(Indian Institute of Horticultural Research)
Bhubaneswar



National Seminar-cum-Workshop on
**STRATEGIES FOR IMPROVEMENT, ENHANCING
PRODUCTIVITY AND UTILIZATION OF CUCURBITS**

08-10 August, 2014

Central Horticultural Experiment Station
(Indian Institute of Horticultural Research)
Bhubaneswar

Souvenir & Book of Abstracts

Editors
L.K. Bharathi
P. Srinivas
M. Pitchaimuthu
H. S. Singh

Jointly Organized by
Central Horticultural Experiment Station, Bhubaneswar
&
Society for Promotion of Horticulture, Bengaluru

Publication Sponsored by
National Bank for Agriculture and Rural Development

Correct Citation

Bharathi, L.K., Srinivas, P., Pitchaimuthu, M. and Singh, H. S. 2014. Souvenir & Book of Abstracts. National Seminar-cum-Workshop on Strategies for improvement, enhancing productivity and utilization of cucurbits, 08-10 August, 2014, Central Horticultural Experiment Station (Indian Council of Agricultural Research – Indian Institute of Horticultural Research) Bhubaneswar, Odisha.

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Published by

President

Society for Promotion of Horticulture

IIHR, Bengaluru

Typeset by

Sri. Bhaktahari Dash,

Print-tech offset Pvt. Ltd.

F-66/1 & F-66/2, Chandaka Industrial Area

Bhubaneswar, Odisha - 751024

Sri. G.S. Rao, Technical Assistant,

CHES, Bhubaneswar

Printed By

Print-tech offset Pvt. Ltd.

F-66/1 & F-66/2, Chandaka Industrial Area

Bhubaneswar, Odisha - 751024

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FOREWORD

As a result of agricultural evolution process, formerly underutilized crops are now being globally considered as potential crops, especially due to their significant nutraceutical value and improved market demand. The Old World cucurbits like pointed gourd, ivy gourd, bottle gourd, bitter gourd, sweet gourd, teasel gourd, spine gourd, ash gourd, sponge gourd, ridge gourd and some native melons are broadly cultivated in India and several South-East Asian countries. However, these crops have not yet been studied thoroughly due to supply and use constraints, in spite of their huge potential for commercial exploitation and their popularity in specific geographical pockets. These constraints are borne out of poor yield and shelf life, unrecognized nutritional value and poor consumer awareness. Though cucurbits are being traditionally grown in India since long time, the crop improvement strategy using advance scientific technologies and utilization is still poor. There is an urgent need to characterize and conserve the native cultivars spread across the country, improve the qualitative and quantitative attributes of the local genotypes through modern breeding techniques, produce quality planting material and making them available across different areas with similar climatic conditions, explore their post-harvest potential for development of products and export.

Demand for cucurbitaceous vegetables like bitter gourd and sweet gourd has increased in international market due to the presence of rich health promoting compounds such as lycopene and α -carotene in sweet gourd, or charatin present in bitter gourd, which are known for significant health benefits. Indigenous cucurbits like *gantola(kakrol)* and *kundrucan* can be exploited for export market in the line of gherkin. Sweet gourd also has huge export potential for its paste, powder, juice etc., due to its high nutraceutical value.

With this background, the present seminar on "*Strategies for Improving Production, Productivity and Utilization of Cucurbits*" is being organized to bring together the knowledge base of eminent scientists engaged in research of various cucurbitaceous vegetables. The outcome of the seminar would serve as a guide for future course of research activities on indigenous cucurbits.

I take this opportunity to express my sincere gratitude to all the staff and volunteers who are continually working hard for organizing this seminar.



H. S. Singh
Principal Scientist & Head
Central Horticultural Experiment Station,
Bhubaneswar.

PREFACE

In India, a number of major and minor cucurbits are cultivated accounting for approximately 5-6 % of the total vegetable production. Although considerable progress has been made in the research on watermelon, cucumber and muskmelon, little progress has been made in other cucurbit crops mainly due to supply and use constraints. In spite of the huge potential for commercial exploitation of old world cucurbit like sweet gourd, the crop improvement strategy using advance scientific technologies and utilization is still poor. Therefore, this national workshop has been conceived to bring out the specific recommendations and strategies for improving production, productivity and utilization of cucurbits in South-East Asia in general and India in particular. The seven technical sessions spanning over three days having four to five invited lectures from the specialized speakers, during the Seminar will address various critical issues.

I take this opportunity to thank Hon'ble DDG (Horticulture), ICAR, who is the real inspiration behind the organization of this National meet on cucurbits. He has been the continuous driving force behind the conceptualization and organization of this national event. I also thank The Director, Indian Institute of Horticulture Research and the Head, Central Horticultural Experiment Station for providing me this opportunity in organizing this national seminar. The help rendered by Dr. SK Malhotra, Sh RS Gopalan, IAS, Sh. SK Chadha, IFS, Dr. M. Muthukumar, IAS, Dr. V. Karthikeya Pandian, IAS, is gratefully acknowledged. I also thank all the members of National Advisory Committee and Organizing Committee of the Seminar; Office bearers and Executive committee members of the Society for Promotion of Horticulture, Bengaluru; fellow colleagues of IIHR, Bengaluru and CHES, Bhubaneswar. Special appreciation goes to Dr P. Srinivas, Dr. C. Aswath, Dr. M. Pitchai Muthu, and Sh. Arun Kumar Das, who made significant contribution at various stages for organizing this seminar.

I would also like to place our gratitude to our major sponsors namely National Horticulture Board, NABARD, Institute of Management of Agricultural Extension (IMAGE), Bhubaneswar, Directorate of Horticulture, Odisha, Indian Society for Root Crops, Thiruvananthapuram, Deputy Director of Horticulture, Balangir, Head, Central Horticultural Experiment Station, Bhubaneswar. Grateful thanks are due to Lakeshwar enterprises, Bolangir, Krishak Sathi, Cheminova, Blue Stal, Good Earth, Mohapatra Scientific supply syndicate, Hindustan Seeds, who gave financial assistance in the form of advertisements in the souvenir. The financial assistance received from Research and Development Fund of National Bank for Agriculture and rural Development (NABARD) towards publication of journal printing of proceedings of the seminar is gratefully acknowledged.

I am sure the workshop would generate meaningful discussions and come out with strategies for improvement and expansion of cucurbits in India. The strategies would be helpful to different agencies for consideration in framing policies and programmes for future R & D activities.

I welcome the participants and wish them a happy stay.



Organizing Secretary

MESSAGES



MESSAGE

I am glad to know that Central Horticulture Experiment Station, Bhubaneswar and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar-cum-Workshop on 'Strategies for Improvement, Enhancing Productivity and Utilization of Cucurbits' on August 8-10, 2014. A souvenir is being brought out on the occasion.

Cucurbits are largely grown or wild gathered and sold in the market by small and marginal farmers of Odisha. Odisha harbours a rich diversity like spine gourd, melothria, coccinia, bitter gourd, sweet gourd etc and has ideal climate to cultivate these cucurbits. Hence promotion of these holds key to ensuring livelihood security to the tribal's and others in remote rural areas. The seminar, I hope, will chart out a concrete blueprint on the future course of action.

I wish the endeavor all success.

A handwritten signature in black ink, appearing to read "jamir".

(S. C. JAMIR)

NAVEEN PATNAIK
CHIEF MINISTER, ODISHA



Telephone { (0674) : 2531100 (Off.)
(0674) : 2591099 (Res.)
Fax { (0674) : 2535100 (Off.)
(0674) : 2590833 (Res.)
E. Mail—cmo@ori.nic.in

D. O. No. 311

BHUBANESWAR

Dated 26.10.14.

M E S S A G E

I am glad to know that the Central Horticultural Experiment Station, Bhubaneswar and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar-cum-Workshop on "Strategies for improvement, enhancing productivity and utilization of cucurbits" from 8th to 10th August, 2014 in Bhubaneswar.

Odisha is home to a large number of indigenous cucurbits crops. These crops require strong research support for better production and utilization. I hope this seminar will provide a platform for the scientists, development agencies and the growers from all over the nation to discuss various issues for resolving major production constraints.

I extend my warm greetings to all the delegates of the Seminar and hope the deliberations will pave the way for enhanced production of quality cucurbits. I wish the seminar all success.

(NAVEEN PATNAIK)

SHRI PRADEEP MAHARATHY
MINISTER
Agriculture, Fisheries & Animal
Resources Development
Odisha



Tel. { Telefax : (0674) 2536941(O)
EPABX: 2322179

D. O. No.239...../MAF&ARD.

BHUBANESWAR

Date... 24/7/2014



MESSAGE

I am happy to know that a three days' National seminar cum workshop on "Strategies for Improvement, enhancing productivity and utilisation of cucurbits" is being organized by Central Horticultural Experiment Mission, Bhubaneswar on 8th, 9th and 10th August, 2014.

The National seminar on "Strategies for Improvement, enhancing productivity and utilisation of cucurbits", I hope, would be an eye-opener in enhancing productivity and utilisation of cucurbits and formulating future strategies in the related sphere especially in the context of our state.

I wish the seminar cum workshc

(Pradeep Maharathy)



डा. एस. अय्याप्पन
सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL



भारत सरकार
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कृषि मंत्रालय, कृषि भवन, नई दिल्ली 110 001

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DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE, KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

MESSAGE

I am happy to know that Central Horticultural Experiment Station, Bhubaneswar of the Indian Institute of Horticultural Research, Bengaluru is organizing a National Seminar cum Workshop on “*Strategies for improvement, enhancing productivity and utilization of cucurbits*” jointly with Society for Promotion of Horticulture, Bengaluru at Bhubaneswar on 8-10 August, 2014. With tremendous genetic diversity in the family Cucurbitaceae, the Indian subcontinent offers a great opportunity to the scientific community to explore and exploit their potential to increase the food basket of the country. The range of adaptation for cucurbit species includes tropical and sub-tropical regions, arid deserts, and temperate locations. Despite the important role of these indigenous cucurbits in the livelihood of local communities, few efforts have been made to identify the constraints and strategies to improve these crops.

I hope the delegates would deliberate upon the strategies for improving productivity, utilization and expansion of cucurbitaceous vegetables in India and come out with concrete recommendations to facilitate productivity enhancement of cucurbits in the country.

I wish the Seminar, a great success.

(S. Ayyappan)

Dated the 22nd July, 2014
New Delhi

डा. एन.के. कृष्ण कुमार

उप महानिदेशक (बागवानी)

Dr. N.K. Krishna Kumar

DEPUTY DIRECTOR GENERAL (Horticulture)



भारतीय कृषि अनुसंधान परिषद

कृषि अनुसंधान भवन-II,

पूसा, नई दिल्ली 110 012

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

KRISHI ANUSANDHAN BHAVAN-II,

PUSA, NEW DELHI 110 012



Message

No vegetable group in India is as diverse as the cucurbits. They are adapted to diverse soil and climatic conditions and contribute significantly to total vegetable production. Rightly the cucurbitaceous vegetables have been taken up for intensive research by both Public and Private Sector organizations on aspects like introgression of genes for enhancing productivity, resistance to biotic and abiotic stress etc. Of late, Marker Assisted breeding and genomic studies have improved our understanding of complex characters and provided the basis for evolving effective breeding strategies. Success in inter-specific hybridizations involving wild germplasm has opened new avenues. The successful implementation of the knowledge gained through these studies will have far reaching impact on their wide utilization. Traditional breeding towards improving productivity now need to reorient its approach and incorporate resistance to biotic and abiotic stresses and quality traits.

I am happy to learn that the Central Horticultural Experiment Station, under the aegis of Indian Institute of Horticultural Research, Bengaluru in association with Society for Promotion of Horticulture, is organizing a National Seminar cum Workshop on ***Strategies for improvement, enhancing productivity and utilization of cucurbits*** during 8-10 August, 2014 at Bhubaneswar. It is hoped that the discussion will pave the way for evolving future strategies on improvement, production and utilization of cucurbits for nutritional security in India.

I congratulate the organizers for this initiative and wish the event a grand success.

N. K. Krishna Kumar

(N.K. Krishna Kumar)

Rajesh Verma, I.A.S.
 Principal Secretary to Government
 Agriculture Department
 Government of Odisha, Bhubaneswar



Tel. : 0674-2391325 (O)
 0674-2323049 (O)
 Fax : 0674-2393948
 E-mail : agrsec.or@nic.in

No. : /Agril.
 Date : 25 - 07 - 2014



MESSAGE

I am extremely happy to know that Central Horticultural Experiment Station, Bhubaneswar and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar-cum-Workshop on "***Strategies for improvement, enhancing productivity and utilization of cucurbits***" from 8-10 August, 2014 and bringing out a Souvenir on the occasion. The Horticultural activities of the State have come to the limelight with the implementation of National Horticulture Mission, Rashtriya Krishi Vikas Yojana and other programmes. Significant strides have been made in the expansion of area under fruits and vegetables.

Vegetable cultivation has the unique advantage of higher income per unit area. With increasing scarcity of labourers, cucurbits cultivation combined with trellising, mulching, drip irrigation and fertigation hold immense potential and promise for future vegetable enterprise in Odisha. I hope this congregation of experts on cucurbits in Bhubaneswar will propose future course of action for promotion of cultivation of cucurbits in India.

I wish the National Seminar a grand success.

(Rajesh Verma)



Prof. M. Kar
VICE CHANCELLOR



Dated the 19th July, 2014

MESSAGE

I am happy to know that the Central Horticultural Experiment Station, Aiginia, Bhubaneswar, Odisha is going to organize a National Seminar-cum-Workshop on “Strategies for improvement, enhancing productivity and utilization of cucurbits” during 8th-10th August, 2014 and to mark the occasion a Souvenir is going to be published. It is a wellknown fact that India is endowed with a rich potential for genetic resources of cultivated as well as wild cucurbits. Though we have made substantial progress in the development of improved varieties in cucurbitaceous vegetables, more research and development is essential to explore the potential of cucurbits for pharmaceutical and nutraceutical industries. Sustainable and ecofriendly agricultural practices have attained immense significance as a tool for climate change adaptation. It is disheartening to note that the old World cucurbits like pointed gourd, ivy gourd, bitter gourd, sweet gourd, spine gourd, ash gourd, ridge gourd, native melons etc. cultivated in India and several South-East Asian countries have not yet been studied thoroughly due to various constraints despite their huge potential for commercial exploitation. There is an urgent need to organize the Indian research efforts and channelizing them towards improving productivity, utilization and expansion of cucurbits in India. I am sure during the three days deliberations scientists from SAUs and ICAR institutes will be able to come out with valid recommendations and formulate future strategies to improve productivity, utilization and expansion of cucurbits in new areas.

I wish the symposium and the publication a grand success.


(M. Kar)
19/7/14



Dr. S.K. Malhotra
Horticulture Commissioner
Tel : 011-23381012
Fax : 011-23383712
Email : hortcommissioner@gmail.com

भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
कृषि भवन, नई दिल्ली- 110 001
GOVERNMENT OF INDIA
MINISTRY OF AGRICULTURE
(DEPARTMENT OF AGRICULTURE & COOPERATION)
KRISHI BHAWAN, NEW DELHI-110 001



MESSAGE

I am pleased to know that IIHR, Central Horticultural Experiment Station, Bhubaneswar is organizing the National Seminar cum Workshop on “*Strategies for improvement, enhancing productivity and utilization of cucurbits*” in collaboration with Society for Promotion of Horticulture at Bhubaneswar from 8-10 August, 2014.

India is known for growing wide range of cucurbitaceous crops with broad adaptation to tropical and subtropical regions, arid deserts and temperate regions. There has been appreciable research and developmental efforts for evolution of new varieties, better production and protection system. There is enough scope of improvement of cultivated and wild cucurbits for resistance to diseases and tolerance to pests. Some of the cucurbitaceous crops are known for unique medicinal (bitter gourd, bottle gourd) and nutritional properties (ash gourd). Though these cucurbits do not contribute much as basic foods, yet they do contribute significantly to diversify the human diet. Further, they provide important chemical compounds for the nutraceutical industry and most importantly has the potential to act as source of additional income for farmers.

In the present scenario, there is need to take stock of the situation and develop strategies for enhancing productivity and utilization of cucurbits. I hope that all related issues shall be discussed in this seminar.

I wish the seminar a great success.

(S.K. Malhotra)



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Hessaraghatta Lake Post, Bengaluru - 560 089



◆ Sardar Patel Outstanding ICAR Institution Award 2010 ◆

DR. T. MANJUNATHA RAO
DIRECTOR (Acting)



Dated : 4th August, 2014

MESSAGE

I am happy to learn that Central Horticultural Experiment Station, Bhubaneswar the regional Station of Indian Institute of Horticultural Research, Bengaluru is organizing the National Seminar cum Workshop on “*Strategies for improvement, enhancing productivity and utilization of cucurbits*” jointly with Society for Promotion of Horticulture, Bengaluru at Bhubaneswar during 8-10 August, 2014. It is high time that the age old cucurbitaceous vegetables get their righteous due importance. The cucurbits have huge potential to significantly increase the income of the small and marginal farmers who still lack the proper scientific knowledge of optimum cultivation practices of cucurbits. Identification of trait specific accessions and trait specific pollen donors from the Indian cucurbit genetic pool for introgression of genes for enhancing biotic and abiotic stress resistance and other qualitative traits. Success of inter-specific hybridization involving wild germplasm with desirable traits have opened new avenues. Genomic studies are improving our understanding of complex characters as well as providing the basis for effective breeding strategies. The successful implementation of these studies to cucurbits will have an impact on their wider utilization. Traditionally, most of the breeding work is directed towards improving productivity. However, the breeding programs should now shift towards development of biotic and abiotic resistant varieties/hybrids coupled with quality attributes on sustainable basis. I hope this National Seminar cum Workshop on cucurbits being organized at Central Horticultural Experiment Station, Bhubaneswar will bring out the strategies for further improvement, utilization and expansion of cucurbits.

I congratulate the organizers for this timely initiative and wish the Seminar cum Workshop a grand success.

(T. MANJUNATHA RAO)

Dr.T.Janakiram
Assistant Director General (HS.I)



भारतीय कृषि अनुसंधान परिषद

कृषि अनुसंधान भवन-II,
पूसा, नई दिल्ली 110 012

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI ANUSANDHAN BHAVAN-II,
PUSA, NEW DELHI 110 012



MESSAGE

It is heartening to know that Central Horticultural Experiment Station, Bhubaneswar and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar cum Workshop on “*Strategies for improvement, enhancing productivity and utilization of cucurbits*” from 8-10 August, 2014. Though cucurbits are being cultivated since the dawn of civilization most of the cucurbits are still lack proper cultivation packages. In Odisha large number of indigenous cucurbits are grown and these crops require strong research support for better production and utilization. I hope this seminar will provide a platform for the scientists, development agencies and the growers from all over the nation to discuss various research and development issues for resolving major production constraints.

I have learned that delegates from across the country shall be participating and presenting their perspectives to develop new technologies during the deliberations. I am sure the seminar will pave a way for increased production of quality cucurbits in our country.

I wish the seminar a grand success.

(T.Janakiram)



ଆମ୍ବା ଏତ୍ତ ଗୋପାଳନ, ଡାଃସ୍ରୀ

R. S. GOPALAN, IAS

Director, Agriculture & Food Production
Government of Odisha, Bhubaneswar
Ph.: +91-674-2395532, Fax : +91-674-2391327
E-mail : diragri.or@nic.in



MESSAGE

I am delighted that the Central Horticultural Experiment Station, Bhubaneswar and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar-cum-Workshop on “*Strategies for improvement, enhancing productivity and utilization of cucurbits*” from 8 -10 August,2014.

Many cucurbits are good sources of carbohydrates, beta carotene, vitamin C and minerals; bitter gourd has been used for diabetes, sweet gourd seeds are cure for arthritis and asthma in traditional Indian medicine. I hope this seminar would further explore the potential nutraceutical and pharmaceutical properties of Indian cucurbits.

I wish the seminar a grand success.

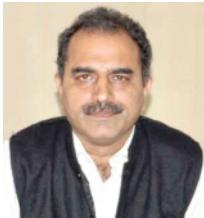
23 July 14

(R.S.Gopalan,IAS)



Dr. Sanjeev Kumar Chadha

Director of Horticulture & Secretary, OHDS



MESSAGE

I am pleased to know that Central Horticultural Experiment Station, Bhubaneswar and the Society for Promotion of Horticulture, Bengaluru are organizing a National Seminar cum Workshop on “*Strategies for improvement, enhancing productivity and utilization of cucurbits*” from 8-10 August, 2014 at Bhubaneswar and coming out with a Souvenir on the occasion. The Horticultural activities have gained momentum in the State due to implementation of National Horticulture Mission, Rastriya Krishi Vikas Yojana and other programmes. Some notable achievement have been made during last few years. Protected cultivation of various Horticultural crops especially rose, gerbera and vegetables is gaining popularity. Attention needs to be paid for post harvest management of the produces to ensure better remuneration to the farmers. Among the vegetables cucurbits play a major role in the State of Odisha. Government have popularized single line trellies system for small cucurbits and introduced hybrid seeds in Government system. I extend my best wishes for the workshop and hope for a meaningful recommendation for the development of cucurbits in the country.

I wish the workshop a grand success.

(Dr. S.K. Chadha)

SOUVENIR ARTICLES

Introgression of wild genes for trait specific improvement with special reference to cucurbitaceous vegetables

N. K. Krishna Kumar¹ and V. Pandey²

¹Deputy Director General (Hort. Sci.), ²Pri. Sci.(Hort.)

Horticultural Science Division

Indian Council of Agricultural Research

Pusa, New Delhi-110012

¹email:ddghort@gmail.com

Introduction

Wild species have played significant role crop evolution and in addressing the challenges of biotic and abiotic stresses. Of late, wild relatives have also been useful in improvement of quality in terms of nutrient content. Historically, ~56% of wild relatives used are associated with biotic stress, 13% with abiotic stress, 10% with enhancing yield, 11% with quality improvement and 4% with male sterility and fertility restorations (Maxted and Kell 2009).

With the advent of assisted hybridization with in a species, breeders have been able in introgression of desired characters in to the cultivated varieties. Further, success of distant hybridization between individuals of different species or genera provides additional way to combine diverged genomes to create genotypes with characters hitherto unknown in the particular species. Distant hybridization also offers an opportunity to improve existing cultivars by incorporating specific traits, such as pest and stress resistance, from their wild relatives through different breeding methods. The interest in distant hybrids has grown with the discovery of related wild species of plants possessing valuable distinguishing traits like resistance to biotic & abiotic stress, nutritional quality etc. First inter specific hybrid between *Nicotiana rustica* and *Nicotiana paniculata* was successful during second half of the eighteenth century. Thereafter, several attempts have been made with an objective to broaden the genetic base of the cultivated species, and to introduce abiotic and biotic stress resistance from the wild relatives to their cultivated counterparts. As a result large number of interspecific/generic hybrids has been developed. Economically, it has been difficult to quantify the value of the wild relatives in agriculture. However, available reports indicate significant economic gains. The estimates on economic value of gene introgressions from wild relatives indicate its worth to the tune of US\$115 billion per year (Pimentel et al. 1997) while the value of products derived from the exploitation of plant genetic resources stands at US\$500-800 billion per year (Kate and Laird 1999).

Challenges in distant hybridization

Challenges in distant hybridization are governed by the nature and the plant species. The difficulty in production of distant hybrids varies from failure of fertilization to no fruit set to high fruit set with or without seeds. The barriers to wide hybridization can be broadly divided as the barriers that operate before fertilization and after fertilization. The pre-fertilization barriers might be due to failure of pollen germination, slow, short and poor pollen tube growth, or failure of pollen tube penetration of the ovule, the release of gametes for fertilization. Post-fertilization barriers arise from embryonic breakdown, failure of zygotic development, abnormal fertilization, faulty endosperm development, inhibition of embryo development, male and/or female sterility in the hybrid progeny, and lethality in the hybrid progeny. The nature of fertilization barriers vary from species to species. In the genus *Momordica*, the failure of the cross between *M. charantia* and *M. dioica* were attributed to poor pollen germination and inhibition of growth of pollen tubes in the upper part of the style before reaching the embryo sac. Obstruction in transfer of male gametes and fertilization could be due to abnormal behaviour of pollen tubes and heavy deposition of callose at the tip of the pollen tube. However, in most of the cases, post-fertilization barriers operate between species and this situation is very common in certain vegetables like tomato, okra, brinjal, beans, cucumber etc.

Achieving success through distant hybridization requires knowledge on the mechanisms crossability behavior, fertilization barriers, breaking hybridization barriers, methods to restore the fertility, inheritance pattern etc. Distant hybridization, however, brings more practical results in crosses between genetically closer species rather than hybridization between taxonomically distant species. Many a times, it is accompanied by considerable difficulties like chromosomal, genetic, cytoplasmic, or mechanical isolation barriers. Under these circumstances, considerable efforts are required to make successful distant crosses and obtain an inter-specific hybrid, between cultivated and wild species, bearing desirable gene of interest. Traditional and modern both the approaches like application of growth regulators, use of mentor pollen, pollen irradiation, early pollination, bud pollination, repeated (double/triple etc.) pollination, use of bridge species, back crossing, doubling of chromosome, fusion of protoplasts, embryo rescue may be attempted to overcome the barriers to distant hybridization.

In general, the pre-fertilization barriers between cultivated species and their wild relatives can be overcome by means of bud pollination and using wild species as the female parent. Application of mentor pollen in the cross *Cucumis metuliferous* × *C. africanus*; early stage pollination in the cross *S. subtelius* × *S. caldesi* and cutting of style in the cross *S. pinnatisectum* × *S. bulbocastanum* hybrid are some of the effective strategies that yielded seeds in the hybrid. Backcrossing has been successfully used to restore the female fertility of the F_1 hybrid developed between

M. dioica and *M. subangulata* subsp. *renigera*. Researchers have developed effective *in vitro* culture techniques to rescue hybrid embryos that would otherwise degenerate during the early stages of their development in distant hybridizations. In vegetable crops, numerous novel F_1 hybrids have been produced by using various embryo rescue techniques like ovary culture, ovule culture and placenta culture. In some other approaches, a species compatible with both the species (bridge species) has been utilized to make successful interspecific hybridization between two incompatible species. For example, *Solanum pinnatisectum* was used as bridge species between *S. tuberosum* and *S. bulbocastanum* to introduce the genes of the later into the former species.

The disparity in respect of number of chromosomes between prospective species can be overcome by measures like doubling the chromosome number. Such induced polyploidy measures have facilitated gene transfer between some related species when crossed at different ploidy levels. After doubling of the chromosome numbers many wild species of potato have been successfully hybridized with *S. tuberosum*. Successful construction of an allopolyploid/amphidiploid results in the creation of a new genome combination, or the production of a species that, as such, did not exist previously. In the family Cucurbitaceae, *Cucumis hytivus* has been derived between *C. hystrix* and *C. sativus*. These amphidiploid lines derived from hybrids between cultivated crops and their wild relatives have also been used to create genetic stocks in breeding programs, and as bridging materials for the transfer of desirable traits from more wild species into cultivated ones.

The prospect of creating such interesting and useful genotypes attracts breeders and much attention has been paid to this approach recently. Though lot of information has been generated and the same is available in the public domain, for convenience, achievements of wide hybridization in vegetable crops with special reference to cucurbits has been discussed here.

Application of distant hybridization in vegetable crops

There has been extensive use of wild relatives in vegetable breeding programs across the world. While crops like okra and tomato could be referred to outstanding example of the use of wild relatives for genetic improvement, satisfactory beginning and success in other vegetables on distant hybridization has also been made at several places. Despite huge potential as source of valuable genes, the optimal use of wild relatives in vegetable breeding remains limited because of several reasons like interspecies breeding barriers and the long time required to make an optimal use of wild species. In addition, this process involves inter-specific hybridization followed by lengthy process of sequential backcrosses with cultivated species and the effects of linkage drag where the trait of interest exhibits simultaneous linkage with traits with negative impact. However, prospects for utilizing wild relatives are now bright, as it's now possible to expedite the process of introgression faster with biotechnological interventions such as embryo rescue,

molecular breeding and genomics. Application of modern breeding tools such as SNP markers, molecular maps and genomics enable quick, accurate and efficient exploitation of wild relatives.

Cucurbits

Most of the present day resistant varieties in cucurbits have been developed by simple selection and utilization of wild species for introgression of genes has been rare. Though many sources of pest resistance have been identified, only few have been deployed in commercial cultivars. With the advent of new pathogen races and increasing virus disease menace, wild species of cucurbits have been considered as potential candidate crops for gene exchange with the cultivated species. Though extensive research on distant hybridization in the family Cucurbitaceae has been carried out by many workers, but hybrids with commercial significance have been obtained in few genera like *Cucumis*, *Cucurbita*, *Momordica* etc. Moreover, most of the interspecific hybridization studies in genus like *Luffa* have been directed towards revealing phylogenetic relationship, rather than developing hybrids.

Cucumis

Muskmelon (*C. melo*) and cucumber (*C. sativus*) are the two most important species of the genus *Cucumis* cultivated worldwide. Many wild species under the genus *Cucumis* are known to be resistant to biotic and abiotic stresses (Kirkbride, 1993; Leppick, 1966; Lower and Edwards, 1986) but due to the limitation of mutual cross compatibility, their utilization in distant hybridization has been limited. Attempts made to produce fertile F_1 progeny from crosses of *Cucumis metuliferus* with *Cucumis melo* and *Cucumis sativus* in order to transfer several pest resistance traits to melon and cucumber were largely unsuccessful. However, various approaches like back cross, embryo rescue, colchicines induced polyploidy have been used to overcome the fertilization barriers in interspecies hybrids, with some success. *C. sativus* var. *hardwickii*, botanically a close relative of cultivated cucumber, possesses desirable traits like multiple lateral branching, sequential fruiting and resistance to Cucumber Mosaic Virus. As *C. sativus* var. *hardwickii* is cross compatible with the cultivated cucumber (*C. sativus*), these traits can easily be transferred through backcrossing. *C. hystrix* ($2n=24$) which is resistant to root knot nematode, downy mildew, gummy stem blight, *Fusarium* wilt and tolerant to low lights and temperature, was used to develop a successful interspecific F_1 hybrid with *C. sativus* ($2n=14$) through embryo rescue of F_1 hybrid and the later fertility restoration through chromosome doubling (Chen et al. 2002). The resultant amphidiploid was described as a new species (*Cucumis × hytivus* J.F. Chen and J. H. Kirkbr., $2n=38$). This offered the possibility to introduce the desirable characters such as nematode resistance, tolerance to high temperature and low light intensity from *C. hystrix* to cultivated *C. sativus*.

Introgression lines are useful for breeding purposes as the favorable exotic alleles can comparatively easily and rapidly be isolated and transferred into the elite

varieties but otherwise lacking in desired traits. Genetically stable *C. sativus-hystrix* introgression lines resistant to powdery mildew have been reported and these lines could possibly be used as bridging lines for transferring desirable traits from *C. hystrix* to *C. sativus*.

Cucurbita

The genus *Cucurbita* native to Americas comprises of five cultivated species and >20 wild species. Several attempts have been made to produce interspecific hybrids among cultivated and non-cultivated species. Although all the species of *Cucurbita* have $2n=40$, the exchange of genes is difficult due to sterility barriers. However, *Cucurbita okeechobeensis* ssp. *martinezii* was successfully used in crosses with *Cucurbita maxima* and *Cucurbita pepo* to transfer powdery mildew resistance to these two species. *C. moschata* is resistant to squash bug and squash vine borer, while *C. maxima* is susceptible and therefore, would benefit from genes of *C. moschata*. First generation F_1 hybrids between these two species have been developed which combined desired trait for good quality pulp of *C. maxima* and insect resistance of *C. moschata* (Pearson et al. 1951). However, destabilization of desirable character combinations due to sterility needs to be tackled in further research. Powdery mildew resistant genes of *C. lundelliana* have been transferred to *C. maxima* and *C. pepo*. In addition, *C. lundelliana* can serve as a bridge species to transfer genes between species that are difficult to cross. At Cornell University, *C. moschata* was used as bridge species to transfer disease resistance genes from *C. martinezii* to *C. pepo* (Vaulx and Pitrat 1979). Bush cultivars of *C. moschata* have been developed from crosses with *C. pepo*. Amphidiploids have also been developed to overcome the problem of sterility in crosses like *C. maxima* × *C. moschata* and *C. foetidissima* × *C. moschata*.

Momordica

The genus *Momordica* comprises 59 species distributed in the warm tropics, mainly in Africa and in South East Asia. The wild species of *Momordica* offer great resource for improvement of cultivated bitter gourd for desirable traits pertaining to quality, biotic and abiotic stresses. Most of the interspecific hybridization efforts in the genus *Momordica* could not sustain beyond F_1 hybrid due to high sterility. However, extensive efforts made at Central Horticultural Experiment Station, Bhubaneswar led to a fertile back cross progeny between *M. dioica* and *M. subangulata* subsp. *renigera* which may be used as a fertile bridge for crosses to either parent to maximize the recovery of the elite traits (Bharathi et al. 2014a). This study clearly indicated that the interspecific hybrids can be produced with introgression of genes for quality from spine gourd (*M. dioica*) and for adventitious root structure and long cropping period from teasel gourd (*M. subangulata* subsp. *renigera*). Also, a new synthetic species (*M. × suboica* Bharathi, $2n=56$) could be developed by manipulation of ploidy level between the species of different ploidy by crossing natural tetraploid (*M. subangulata* subsp. *renigera*) and induced tetraploid

(*M. dioica*). The hybrid which is naturally fertile, combined the superior traits of both parents like production of adventitious root tubers, natural pollination, and high culinary quality, making it a good choice as a new vegetable crop in traditional spine gourd and teasel gourd growing areas of India and south east Asia (Bharathi et al. 2014b).

Citrullus

The genus *Citrullus* is represented by three species *C. lanatus*, the cultivated water melon, *C. lanatus* var. *citroides*, cultivated as fodder watermelon and *C. colocynthis*, a medicinal cucurbit. These species are freely crossable with high bivalent frequency. A naturally occurring interspecific hybrid between these two species has also been reported (Singh 1978). Interspecific hybrid between these two species would improve *C. colocynthis* with larger and higher number of seeds.

Luffa

The genus *Luffa* consists of seven species, four well differentiated species of the Old-world tropics and three species of the Neotropics. The genus includes a commercial vegetable crop *L. acutangula* and a crop of industrial potential *L. cylindrica*. A number of interspecific hybridizations have been done among the species of old world species. Though both way crosses between these two species are successful, the hybrids are highly sterile (Dutt and Roy 1971) and most of the interspecific studies conducted to study the evolutionary history and drive phylogenetic relationship. The fertility can however, be restored through back crossing. Amphidiploid produced between *L. acutangula* and *L. graveolens* through colchicine treatment was sterile. Interspecific hybrids have also been attempted between the species of the Old and New-world. Singh (1991) obtained a fertile inter-specific hybrid has been obtained between *L. operculata* (New-world species) and *L. hermaphrodita* (Old World species).

Other vegetables

Distant hybridization has also been widely used in vegetable crops like potato, tomato and okra to develop disease resistant varieties. For improvement in okra, *Abelmoschus manihot* var. *tetraphyllus* has been widely used for development of varieties with yellow vein mosaic resistance. Virus resistant potato varieties were developed by utilizing the resistance genes from *Solanum tuberosum* subsp. *andigena* and *S. stoloniferum*. Most of the German potato varieties have the resistant genes for late blight, leaf roll and potato virus Y from *S. demissum*. Wild species like *S. phureja* and *S. vernei* were used as gene donor in development of varieties resistant to bacterial wilt and nematode, respectively.

Several achievements have been made in development of tomato varieties resistant to diseases with enhanced fruit quality. A large number of resistant genes have been transferred from wild species to cultivated tomato for diseases like mosaic, *Fusarium* wilt and root knot nematode. In 1950's, hybrids resistant to *Fusarium* wilt

were developed at University of Honolulu in Hawaii by using *Lycopersicon peruvianum* as one of the parent. Hybrids resistant to different races of *Cladosporium* were obtained at the experimental station of Ontario (Canada) by using *L. hirsutum* in the cross. *L. esculentum* var. *ceraciforme* has been used to develop resistant varieties against leaf mold, fruit anthracnose, leaf spot and *Verticillium* wilt. Resistance genes for *Fusarium* wilt, bacterial wilt, spotted wilt virus, late blight, bacterial canker from *L. pimpinellifolium* and against root knot nematode, Tobacco Mosaic Virus from *L. peruvianum* have also been transferred to cultivated tomato varieties. *L. pimpinellifolium* has been used to develop varieties with high ascorbic acid content while *L. minimum* for high soluble solid content. *L. hirsutum* f. *glabratum* and *L. pimpinellifolium* species are being used to develop leaf curl virus resistant varieties. Wide hybridization has the scope to nurture the wild ideas like development of tomato plant bearing fruit enclosed within a bladder-like calyx, as in *Physalis*. Such a character has the potential to solve the problems of tomato storage and transport.

Introgression of resistance genes for downy mildew and botrytis leaf blight from *Allium roylei* to *A. cepa*, cytoplasmic male sterility from *A. galanthum* to shallot (*A. cepa* var. *aggregatum*) and bunching onion (*A. fistulosum*) are few successful examples in the genus *Allium*.

In Brassicaceae, amphidiploids developed from the cross between *Raphanus sativus* and *Brassica oleracea* resulted in a hybrid having roots like cabbage and foliage like radish. Since the development of *Raphanobrassica*, a number of inter-specific and inter-generic hybrids have been produced in Brassicaceae with the aim of developing potentially more useful cultivars with improved biotic and abiotic stress tolerance. Synthetic fertile amphidiploid lines like 'Hakuran' (*Brassica campestris* × *B. oleracea*), 'Radicole' (*Raphanus sativus* × *B. oleracea*), and 'Raparadish' (*B. campestris* × *R. sativus*) have been developed which can be used as genetic stocks in breeding programs, and as bridging lines for the transfer of desirable traits from wild species into cultivated ones (Kaneko and Bang 2014). Distant hybridization has been used to transfer self-incompatible allele from *B. campestris* subsp. *rapifera* to *B. napus* and used to recover male sterility in the cross *B. nigra* × *B. oleracea*.

Future Thrusts

Information gathered on plant genetic resources, phylogenetic relationship, hybridization barriers and their mitigation should be exploited for use in distant hybridization for pooling agronomically important traits. Basic researches on vegetable breeding in India has relied to a great extent on knowledge on gene introgressions reported in literature. Therefore, there is a need to orient national breeding programs towards exploiting these resources and to find solutions to India-specific problems. The genetic resources should be screened and trait specific accession or species should be identified for breeding programmes. Homozygous lines can be obtained in a single generation using double haploid

technology, which may tremendously facilitate breeding programmes particularly in the vegetables which are dioecious. Though some technologies are known to overcome hybridization barriers, concerted efforts are further needed to advance the generation beyond F_1 . Application of modern breeding tools such as SNP markers, molecular maps and genomics enable quick, accurate and efficient exploitation of wild relatives. There is a need to identify molecular markers for tightly linked traits of importance in wild species. Identification of novel genes associated with a trait of interest and the genotyping the progenies in a breeding program as an aid to phenotypic selection, are other areas of consideration. Development and utilization of genetic stocks like introgression lines would further ease the introgression of desirable genes into commercial cultivars. Crop and trait based research projects should be developed on a larger scale, and be carried out more proficiently in collaboration of cytologists, embryologists, molecular biologists, biochemists and physiologists for substantial achievements and desired progress.

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An Ethnobotanist's reflections on one of the world's most important food crop families: the Cucurbitaceae

By Joseph Simcox, "The Botanical Explorer"

"Look around you and discover; nature's works are at hand and we have been remiss to notice"

-Joseph Simcox

My own passion for Cucurbits started somewhere before my 5th year, by the time I was 7 I was so excited about them that I asked my parents to give me squash for my birthday. Now some 43 years later I am still

"crazy" about squash and all their kin. As a World Food Plant Ecologist

—one who is a true generalist, it is indeed difficult to claim that I have a favorite plant family, however, if I was held at gunpoint and forced to answer I would have to concede that my favorite group is indeed the Cucurbits! In the years since my first introductions to squash in the gardens of my grandparents and elderly neighbors, I have been blessed to travel around the world dozens of times studying the very same things that fascinated me as a child.

Fortunately for me *and for the sake of biodiversity*, the world is a very big place with lots of things to discover. For a plant eater and plant hunter it is amazing that after all these years of studying that there are still "new" Cucurbits to "discover".

Recently while on a trip to Central America, I was introduced to two extremely impressive Cucurbit species that up till then I was oblivious to. One of them, *Cionosicyos macranthus*, is so obscure that the natives themselves have endowed it with a rather ridiculous "foreign" common name. They call it the "Chinese Passionfruit" insinuating that it came from China when in fact it is an endemic of the region! First learning about the existence of this fruit in a book, my brother and I worked on sleuthing out its whereabouts. We asked dozens of people and then finally we found someone who knew what we were talking about. When they finally took us to a bearing plant I was amazed to find how productive the vine was—as many as a couple of hundred fruits hung from one plant that had climbed over a reasonable tall tree in its search for the sun. The fruits of *Cionosicyos* are gorgeous, a shiny yellow porcelain exterior, that when cut reveals a deep orange-pink flesh that includes a center with seeds floating in the "liquid like pulp"

Both the flesh and the "liquid pulp" are delicious. The natives of Central America who know of the fruit value it highly, they make a drink out of it that is

variously referred to as a “liquado” ... a generic name for fruit drinks that are made in blending machines, sometimes with the addition of milk and sugar to enhance the flavor. The flavor of the Cionosicyos fruit is very akin to that of a very tasty papaya. My brother Patrick Simcox, who is also a Botanical Explorer, said that it was one of the most delicious fruits that he had ever tasted. Having impressed us so, the question we posed is: “Why is this fruit not being globally cultivated in the tropics?”

The second amazing cucurbit species that we “discovered” in Central America grows as an endemic in Costa Rica it is known as “Tacaco”.

Tacaco or *Sechium tacaco* is almost unknown outside of Costa Rica, within the country it is well known, however as diets “modernize” to include more and more processed foods the traditional appreciation for this vegetable seems to be dwindling. My brother and I found untended Tacaco vines growing in profusion on a country road not far from the northern border of Panama. The country folk were basically amused that two “Gringos” were so interested in something that they themselves had come to overlook. The vines that we had discovered were loaded with small 4-6 centimeter long fruits. While young and tender (before the skin hardens and they become fibrous) these Tacacos are one of the most exquisite of vegetables. We harvested several bags of them for our own trials and we were amazed by the edibility of the tender boiled fruits. The taste can vaguely be likened to a summer squash with the qualification that it also tasted “nutty” or even avocado-like. A few scientific papers suggest that it is much more nutritious than its close relative the Chayote, *Sechium edule*.

To our knowledge neither of these extraordinary fruits are being cultivated commercially even in the countries where they are known. It is further proof that promising food plants can easily be lost; if traditions and cultures change. The dilemma is not limited to any particular region but seems to pandemic in occurrence.

A world away in East Africa I was astounded to find that very few people were still cultivating The Eastern African Pumpkin, *Telfairia pedata*. In October 2010 I had traveled to East Africa specifically to track down amazing yet underutilized fruits and vegetables, among them, was *Telfairia pedata*.

I had known of the existence of this amazing plant for many years and was indeed anxious to track it down, the day came when I arrived in Fort Portal. My friend Chris Kaija, of Tooro Botanical Gardens, showed me my first fruit, it was an enormous hanging green orb! This “vegetable” is being ignored, despite the fact that it produces an exquisite giant seed that at one time was exported to England under the name of “Queen’s Nut”. One can only imagine why it is no longer being shipped since at one time it was a real special commodity. Perhaps the trade was interrupted during the horrendous Idi Amin years and never recuperated or was forgotten. In any case the seeds of *Telfairia pedata* are definitely worthy of being called the Queen’s Nut, they are delicious. I acquired several pounds of seeds and had to stop myself from eating my propagation material precisely because they were so tasty! This plant urgently

needs more attention. In Western Africa its close relative is *Telfairia occidentalis*; The African Fluted Pumpkin. Unlike with *T. pedata*, the seeds of *T. occidentalis* need to be cooked before consumption. One of my good friends, Roy Dansforth has been kind enough to send me photos of this enormous fruit. Fluted Pumpkin fruits can get up to a meter long and may have hundreds of seeds. In the west it has also been called Oyster Nut. Presently I am in communication with a Nigerian Professor, Bosa Okoli who is writing a book on the Telfairia. According to him cultivation is actually increasing in Nigeria as it is being promoted as a traditional vegetable.

In Southern Africa, traditional uses of wild plants abound and wild cucurbits are very important resources for nomadic and desert peoples. Southern Africa is rich in wild cucurbit diversity and a great number of the species are not only edible but exquisite food sources. In Western Botswana, my team and I had the incredible opportunity to go on a “desert hunt” with the Kalahari Bushmen. There my objectives were happily fulfilled as we stalked out fruits and plants of many edible cucurbiits, among them; The Gemsbok Cucumber, *Acanthosicyos naudinianus*. The fruit of *A. naudinianus* is somewhat barrel shaped with blunt protuberances poking out of the skin. It looks artificial, like some pastel yellow pet toy. Sources have shared with me that certain forms of the Gemsbok Cucumber exist that are so “sweet” that they can be eaten raw, most, however, still need to be cooked before eating. I had a good laugh when I experimented on my brother telling him to taste a ripe fruit, “How does it taste?” I repeated... “It tastes terrible” he replied ...so most are probably cooked....!!!. The Kalahari Bushman do this creatively by burying the ripe fruits in the ashes of last evenings fire, after a few hours the fruits are cracked open and the liquid interior seeds and all is sucked out much as one could envision someone eating a raw egg after carefully tapping open the top.

Several hundred miles away on the Namibian Coast we came face to face with one of the most enchanting plants on the planet. Growing in swelling dunes not far from the sea is the Nara Melon, *Acanthosicyos horridus*. The Nara is a fruit that I dreamt of, what mystery, a Cucurbit without leaves, that grows in barren sands that produces a relatively large (up to a kilo) fruit that has been revered by the Topnaar people for ages. Both its fruit and seeds are a valuable food resource. While we were there we watched as the Topnaar boiled the ripe melons down to a syrupy concoction and then poured the fruit pulp on to the hot sand. The pulp dries making a type of “fruit leather” which is stored and used later. There is also a commercial aspect to the Nara harvest, known as “Butter Pips” the seeds are collected and sold to South Africa where they are a traditional snack food. Despite these uses the Nara melon is still some obscure oddity. It indeed has potential to be grown as a crop in the right circumstances but little if any attention is being given to it!

With so many species to mention in Southern Africa it is difficult to limit the scope, however, another cucurbit stands unique in the sandy bushlands of the Kalahari. *Cucumis kalahariensis* is not sought out for its fruit but rather its large

tapered juicy white- carrot like- roots! This is such an extraordinary find in the desert that the bushman have come to rely on it as a food and water source in their sojourns. I was able to taste my first “Kalahari carrot” in February 2012, I dug the root out with some bushmen standing overhead... pulling out the root, they motioned for me to clean off the skin, I scraped it off eagerly with my teeth and bit in...delicious! The roots are tender, succulent and crunchy not too unlike Water Apple (*Syzygium samarangense*) fruits. I could easily become an addict of them if left in the desert! To this author’s knowledge little if any effort has been made even to cultivate wild germplasm in trials. Nothing has been done to select varieties, yet its potential for food production in hot desert areas is exceptional. The thin exterior skin of the root although bitter, is easily removed by abrasion making this plant a most promising future food resource.

A world away in my home country, the USA, cucurbits were also used as food resources. Much of the knowledge of that use is long lost. However enough vestiges remain that we can be provoked with the possibilities. Among the possible food crop cucurbits is the so called Buffalo Gourd, *Cucurbita foetidissima*. Both the immature fruit and the seeds have potential. The plant itself produces what has been claimed to be one of the bitterest substances known, nevertheless, the seeds were processed for meal by the Native Americans and are known to be very nutritious. The plant is a gregarious perennial that takes heat, drought and abuse. I love to see their vines sprawling in all directions loaded with yellow fruits as a drive down the back roads in places like West Texas. I have commented to horticulturalist that it would make a wonderful seasonal groundcover for drought susceptible areas, the leaves are glaucous grey and triangular and very pretty. The Buffalo Gourd is treated like an weed by dryland farmers, but what they don’t know is that this weed may one day be someone’s crop.

It certainly needs to be worked with by scientist and the inspired because it has huge potential as a crop for hot dry areas.

In Southern America, there are also wonderfully adapted species of edible cucurbits. The genera *Melothria*, *Cyclanthera* and *Sicana* all being among my favorites. *Melothria dulcis* is a delightful fruit that is filled with a juicy flesh mass not unlike the interior of a passionfruit, in ways it resembles one. I found my first wild *Melothria dulcis* vines along the Pacific Coastal highway in Guatemala. The vines were loaded with ripe fruit and I collected a ton of them and ate them and saved the seeds. The seeds are very unusual because they are resplendently covered with fine “shimmering” golden hairs, making them almost look metallic! *Melothria scabra* has been widely introduced in the United States as a “mini-cucumber” one trade name in which it has marketed in both the US and Europe is “Pepino”. They grow wild on fences all through Mexico and Central America, children relish the green ones, but as word goes, don’t eat the dark black ripe ones—they have powerful laxative properties! The fruits are small; 2-3 centimeters long, but make crunchy, juicy and eye appealing

additions to salads so they are popular with chefs who purchase them to make their entrees more exciting. This fruit has great potential around the world as an annual warm weather crop. *Cyclanthera pedata*, is a plant which has been domesticated by presumably the Incas or their ancestors. It grows in cooler moister conditions and produces bumper crops of large slipper like fruits. The inner cavity is hollow so the mode of use is to scoop the seeds out and fill it with fillings and bake it. I have seen the plant growing and fruiting as north as Oslo, Norway and am presently growing the plant in New England where it is thriving and setting buds. It shows no photoperiod sensitivity, and seems highly adaptable and hardy. It seems to be a very good vegetable resource for moist cooler climates. Several other edible *Cyclanthera* species exist all which are fascinating.

The Casabana, *Sicana odorifera*, is a delightful domesticated cucurbit grown throughout central and southern America. *Sicana* is a monospecific genus. I saw my first fruits years ago while on a trip to Guatemala. Since then I have promoted its cultivation and in recent years it has been grown in the US as a long season annual. It certainly has great potential for further selection, improvement and adaption. Genetic diversity abounds, yellow, chocolate, black, red and orange fruits are known. The fruit is traditionally either baked (much like a squash) or made into fruit smoothies. So fragrant are the mature fruits that they have been used to perfume homes. The young fruits can be cooked and eaten as well. The author hopes that this fruit will find itself being grown all around the planet as have other American cucurbits!

These are just a few of my “global” cucurbit “discoveries”. Every since I was a small child I have been mesmerized by their seemingly endless forms. To write about them here is both nostalgic and inspiring. Nostalgic to recall all of these great adventures, and inspiring because in some small way I hope I have shared something fresh and fun with you the reader. I continue to contend that the scientist citizens greatest tool is passion and curiosity. I hope that I never lose my childlike curiosity, and I hope that you the reader, never does either. Let us share the wonders of nature with all. In the years ahead it is my own hope that many of these most worthy fruits find the attention that they deserve, because, they are *natures gifts* to man.

Endnote: To the astute Cucurbitologist, I have capriciously refrained from mention of Asian Cucurbits, it is this writer’s assumption that the majority of readers will be well versed in the biodiversity of Asian cucurbits.



Scope for integration of genomics with plant breeding in cucurbit crops

Umesh Kumar Reddy

*Gus R. Douglass Institute, Department of Biology,
West Virginia State University, Institute, WV 25112-1000, USA.*

The *Cucurbitaceae* or cucurbit family is a monophyletic clade because of its morphological and biochemical distinctness and represents some of economically important species with edible and medicinal fruits (Whitaker & Bemis, 1976; Robinson & Decker-Walters, 1999). *Cucurbitaceae* is known to have 90 genera and 700 species, out of which there are several domesticated species that includes *Citrullus lanatus* (watermelon), *Cucumis sativus* (cucumber), *Cucumis melo* (melon) and *Cucurbita* (five species of squash & pumpkin). The genome size for watermelon, melon, cucumber and squash are 425Mbp, 454Mbp, 367Mbp and 502Mbp respectively (Arumuganathan & Earle, 1991) and considered to be very small in comparison with other crops such as wheat (15,966 Mbp), tomato (907 Mbp), cotton (2,500 Mbp), onion (15,290 Mbp), pepper (3,420Mbp) and corn (2,716Mbp).

Whole genome sequencing of crop species, facilitated by new sequencing technologies and bioinformatic approaches, has provided new opportunities for crop improvement (Bevan & Uauy, 2013). When combined with resequencing of germplasm accessions to generate thousands of readily usable SNPs, currently researchers are in process of translating genetic variation into phenotypic performance in the field (Elshire *et al*, 2011; De Donato *et al*, 2013). Predictably within the next two years useful reference genome sequences will be available to support the genetic improvement of most of the important food and fuel crops (Bevan & Uauy, 2013). Crop improvement will depend, however, on the identification of useful genetic variation and its utilization by breeding and transformation. Several traits that plant breeders would combine in desirable varieties are polygenic that are of moderate to small effects across multiple loci (Meuwissen *et al*, 2001). Such causative SNPs require identification using strategies like genome wide association studies or scanning breeding populations that are systematically build to pool complex ancestral recombinations (Morrell *et al*, 2011).

Remarkable progress has been achieved in cucurbit crops including cucumber, melon and watermelon by making whole genome sequence available publicly (Huang *et al*, 2009; Garcia-Mas *et al*, 2012; Guo *et al*, 2013). Currently, several cucurbit genome laboratories are focused to perform genotyping by sequencing using next gen sequencing technologies for developing large scale SNP resources. Availability of large scale SNP data would enable to characterize genome wide linkage disequilibrium (LD), a feature where several alleles belonging to extended

loci on chromosomes are in cold spots of recombination, hence would transmit as one whole block from one generation to the next (Han *et al*, 2011; Nimmakayala P *et al*, 2014). The SNP alleles located in these blocks are haplotypes. Haplotyping germplasm for various blocks would resolve genetic diversity more precisely than the individual SNP-types or microsatellite genotypes(Nimmakayala *et al*, 2014). Genome-wide Association Studies (GWAS) is to locate QTLs based on the associations of the traits and SNPs in the LD blocks (Bouchet *et al*, 2012; Peiffer *et al*, 2013; Zhang *et al*, 2013). High resolution maps (HRMs) made using large scale SNPs would be of immense use for genome sequence assembly and further correcting wrongly assembled scaffolds (Delourme *et al*, 2013). HRMs will precisely map QTLs and would in map based cloning of important domains that are useful for marker assisted selection.

Analysis of genetic diversity in world cucurbit collections of various major and minor cucurbits would facilitate to understand LD decay at various levels. Since LD in cucurbits is quite large (Nimmakayala P *et al*, 2014) because of narrow genetic diversity in cultivars, we suggest that the marker sets of the size up to 10,000 SNPs per species with a Minor Allele Frequency (MAF) of 0.05 would be sufficient for conducting a reasonably useful GWAS research. Resequencing strategies to develop million of SNPs for crops such as maize and rice (Jiao *et al*, 2012; Xu *et al*, 2012; Huang *et al*, 2013; Zhai *et al*, 2013) shows what is possible for the cucurbit research community. The identification of SNPs for cucurbits as in previous studies (Nimmakayala P *et al*, 2014) will allow for genome-wide association mapping and marker-assisted selection to support breeding programs.

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SCOPE AND IMPORTANCE OF CUCURBITS IN ODISHA

M. Kar¹ and H.N Mishra²

Orissa University of Agriculture and Technology, Bhubaneswar

¹Vice Chancellor, OUAT, ²Professor & Head, Dept. of Vegetable Science, OUAT

Introduction:

Cucurbits belongs to family Cucurbitaceae, having about 118 genera and 825 species. In India, a number of major and minor cucurbits are cultivated, which share about 5.6 % of the total vegetable production. Cucurbits coined by Liberty Hyde Baily of USA form an important and a large group of extensively cultivated vegetables in India and other tropical and subtropical countries. This group consists of remarkable range of vegetables, either used as salad (cucumber) or for cooking (all gourds) or pickling (cucumber and other minor ones), or as desert fruit (musk melon and water melon) or candied/preserved (ash gourd& gherkin). These are mostly seed propagated, besides a few vegetatively propagated, like pointed gourd, spine gourd and ivy gourd and also few perennials, like chow-chow. They are of tremendous economic importance as food plant like edible vegetables, fruits or seed and as medicinal plants, especially in the indigenous medical systems like Ayurveda, Siddha, or Unani, etc. They are extensively grown across seasons (summer, rainy and winter) and round the year at some or other pockets or regions. They are cultivated in mixed cropping system, like river bed culture on river sand 'Diara'-an unique, indigenous and improvised system of vegetable forcing, which alone approximately covers 60% of the total area under cucurbits in this country.

The main goal of research on cucurbitaceous vegetables in India is to improve productivity on sustainable basis through developing biotic and abiotic resistant variety/hybrids accomplished with quality attributes. The yield potential of cucurbits could be increased by adopting the standardized agro-techniques and plant protection measures.

Economic Importance of the Family Cucurbitaceae:

- i) The hard dried shell or woody pericarp of species *Lagenaria siceraria* in different shape and form make excellent flasks primitive vessels and utensils. It also used as blow pipe of snake charmer, drum for tambura, soraja etc. in making musical instrument.
- ii) Dried fibrous network of vascular tissue in fruit of Luffa when set free by retting away after tissues affords the well-known fibrous *Luffa* sponge as bath sponge . These are two species in this concern i.e. *Luffa cylindrica* and *Luffa aegyptiaca*.

- iii) Vegetable: Majority of species used as vegetables for common use in kitchen viz. *Lagenaria siceraria*, *Cucurbita pepo*, *Cucurbita maxima*, *C. moschata*, *Luffa aegyptiaca*, *Momordica charantia*.
- iv) Fruits: Raw fruits directly eaten as fruit in ripe or unripe condition. These includes- *Cucumis melo*, *C. sativus*, *Citrulus vulgaris* etc.
- v) Ornamental: Certain vines of the family grown in gardens and walls for ornamental purpose.
- vi) Medicinal: Some species of family possess high medicinal value. Majority of them are laxatives, some are poisonous and some produce useful drugs.
- vii) *Citrullus colocynthis* – pulp of which is purgative and official drug used in dropsy intestinal disorders etc.
- viii) *Trichosanthes dioica* – Pulp of fruit mixed with coconut oil used to cure ear itch root is used in inflammation of lungs in cattle.

Scope of cucurbits in odisha:

- High genetic variability present in these crops has not been fully utilized. This genetic variability can be successfully utilized for the development of high yielding resistant (biotic and abiotic stresses) varieties and F_1 hybrids of cucurbits.
- Efforts should be made to develop suitable varieties and F_1 hybrids which can exploit its full potential under the sandy riverbed conditions.
- Cucumber, summer squash, bitter gourd and gherkin are important low volume, high value vegetables for protected cultivation. Efforts should be made to develop gynoecious parthenocarpic varieties and F_1 hybrids of these above vegetables so that they can be profitably exploited under protected conditions or greenhouse of vegetable farming.
- Cucurbitaceous crop like bitter gourd, bottle gourd, cucumber and gherkin are important from export point of view. Therefore, efforts should be made to develop varieties and F_1 hybrid which can suit the requirement of international market.
- Less-exploited crops like pointed gourd, small gourd, snake gourd, round melon, long melon, snap melon, culinary melon etc. should be given attention.
- Efforts should be made to develop stable tropical gynoecious particularly in cucumber and male sterile lines linked with marker and their utilization in heterosis breeding
- Attempts should be made to develop multiple disease resistant hybrids, more particularly in muskmelon and cucumber

- Due attention to be given for grafting of water melon and musk melon with suitable root stocks of bottle gourd and pumpkin to develop resistance against soil fungi.
- Efforts should also be made to develop varieties and F₁ hybrids of pumpkin, ash gourd, gherkin and bitter gourd, which can suit the requirement of value addition and processing industry.
- Marker added selection (MAS) to be utilized for economically important crops like cucumber and musk melon.

Prospects in Odisha:

Odisha is a treasure house of cucurbitaceous vegetable. The diversity for cucurbitaceous crops of this region has mainly been managed by local farmers, often women. Considerable diversity exists among the regional cucurbitaceous crops including variation in plant type, morphological and physiological characteristics, reactions to diseases and pests, adaptability and distribution. In different part of the state different type of promised germplasm are available which can be exploited in the future for improvement programmes in cucurbits. The distribution, area, production and productivity and important local variety of cucurbits grown in Odisha has been presented in Table 1 to Table 3.

Table 1: Distribution of important cucurbits (growing area) in Odisha:

English name	Scientific name	Hindi or other vernacular name	Local name	Areas of cultivation
Bitter gourd	<i>Momordica charantia</i>	Karela	Kalara	Puri, Khurda, Cuttack, Sambalpur, Keonjhar
Bottle gourd	<i>Lagenaria siceraria</i>	Lauki or Ghiya	Lau	Puri, Cuttack, Sundargarh, Koraput, Phulbani
Water melon	<i>Citrullus lanatus</i>	Tarbzuz	Tarabhoj	Deogarh, Kuchinda, Jajpur, Dhenkanala, Angul, Cuttack, Puri
Musk melon	<i>Cucumis melo</i>	Kharbuza	Kharabhuza	Ganjam, Gajapati, Cuttack, Puri, Balasore, Sundargarh
Pointed gourd	<i>Tricosanthes dioica</i>	Parwal or Potal	Potal	Jajpur, Cuttack, Puri, Sambalpur
Cucumber	<i>Cucumis sativus</i>	Khira	Kakudi	Cuttack, Jajpur, Dhenkanal, Puri
Spine gourd	<i>Momordica dioica</i>	Kartoli	Kankada	Keonjhar, Dhenkanal, Sambalpur, Phulbani
Pumpkin	<i>Cucurbita moschata</i>	Sita phal or Kashi phal	Kakharu	Puri, Khurda, Cuttack, Jajpur, Bhawanipatna, Sambalpur, Balasore, Dhenkanal
Snake gourd	<i>Tricosanthes anguina</i>		Chhachindra	Ganjam, Gajapati, Cuttack, Puri, Balasore, Sundargarh

Table 2: Area, production and productivity of important cucurbits in Odisha (Area in Ha., Production in M.T.)

Crop	2012-13			2013-14		
	Area	Productivity	Production	Area	Productivity	Production
Bitter gourd	11485	9.65	112291	11407	9.71	111762
Bottle gourd	10188	13.42	137894	10188	13.44	138085
Water melon	12582	18.91	242881	12582	18.91	242881
Musk Melon	84	16.72	1371	84	16.71	1371
Cucumber	2454	14.02	34507	2456	14.05	34587
Pointed gourd	2050	14.12	28976	2052	14.12	29005
Other Vegetables	73722	11.10	819383	71441	11.19	798837
Total	112565	12.2	1377302	110210	12.3	1356527

(Sources: Department of Horticulture Data Base, Odisha)

Table 3: Important local variety of cucurbits grown in Odisha

Crop	Areas
Pumpkin	Guamal Local, Baidybati
Bitter gourd	Nakhara Local, Thusi kalara
Ridge gourd	Jajpur Local, Barapati, Penthijanhi
Cucumber	Barapati, Satapatri, Kanteikakudi
Snake gourd	Ganjam Local
Small gourd	Rambha Local
Spine gourd	Chota deshi kankada, Jangali kankada, Phulbani local
Pointed gourd	Baripada Local, Jajpur Local, Bargarh Local

Gaps in diversity related research and development of cucurbits in Odisha:

- Regeneration and cultural practices for many species need to be researched and standardized for their cultivation.
- Threatened species need immediate action for ensuring their continued existence.
- Identification and classification of threatened species need to be done.
- Richness of diversity of *cucurbita* species is yet to be fully inventronized and documented.
- There is a serious gap between research and field needs. The established formal institutions like university departments, departmental research stations and

other rarely consult the farmers and local communities about their problems while pursuing research.

- Need based research needs to be encouraged

Research Accomplishment of OUAT in Nut Shell:

1. CROP IMPROVEMENT

Growth, Yield, Propagation and Taxonomic studies in spine types. (*Momordica dioica Roxb.*)

The study was undertaken for gathering knowledge on taxonomic characters and the extent of variability found in the spine gourd types. According to the study the yield was correlated with the yield. Selection of the type should be made on the basis of long phase of flowering medium size of fruits, more number of fruits, resistance to Epilachna beetle. Desired types can be propagated through vine cuttings. Tubers of 40 gm weight produces more no of cuttings which should be used as planting material. Type 7/2 was found to be the highest yielder among the collected types. (**Mahapatra and Maharana, 1983**)

Taxonomy, Floral Biology and crossability study in *Momordica* Species

The study was made to gather knowledge on taxonomic characters, floral biology of three *Momordica* species, studies in relation to crossability and propagation of these species were made. In India, *M. dioica* (spine gourd), *M. subangulata* subsp. *renigera* (teasel gourd) and *M. charantia* (bitter gourd) are being used as vegetable. The anthesis in *M. cochinchinensis* and *M. charantia* takes place in dawn whereas anthesis in *M. dioica* takes place in twilight hours. *M. dioica* takes 7-22 minutes for flower opening whereas *M. cochinchinensis* and *M. charantia* takes more than two hours. Larger pollen was observed in *M. cochinchinensis*. Pollen viability was highest in *M. cochinchinensis*. Pollen viability was highest *M. charantia*. Hand pollination ensures highest amount of fruit set .No parthenocarpic fruit development was observed in any of the species .Twenty two to twenty eight days are required for fruit development in *M. dioica* whereas 28-36 days were required for the other two species. Seed of fruit ratio is highest in *M. charantia*. All the species crossed within themselves but crossing between *M. cochinchinensis* and *M. dioica* has been successful to is the extent of 70% other reciprocal crosses have been found to be more or less in compatible except *M. dioica* and *M. cochinchinensis* where 5% fruit set was observed (**Sahoo and Maharana, 1984**).

Studies on floral biology of bitter gourd

Studies on floral biology were taken up in thirteen genotypes of bitter gourd namely priya, Green Long, BG-14, Coimbatore Long, Thusi, Long White, Hajipur Local, Tiansi, Pusa Do mousumi, Nakhara Local, Gadabeta, Solan Hara and Solan white. Flower bud development was studied both for male and female flowers in all the varieties. Anthesis stared between 1.30 A.M to 2.30 and anther dehiscence was completed between 12 mid-night and 1.30 A.M even before opening of the flowers in all the varieties stigma was highly receptive at the time of anthesis. Considerable

variation in pollen size, pollen viability and artificial germination of pollen grains was recorded. Existence of parallelism effect between male and female blooming phase in most of the varieties was also recorded considerable variation on sex ratio was observed among various cultivars studied. (**Parhi, Swain and Mishra, 1992**)

Genetic divergence in bitter gourd (*Momordica charantia* L.)

Genetic divergence using Mahalanobis D² statistics was studied for fourteen quantitative characters including yield per plant in a collection of thirteen genotypes of bitter gourd (*M. charantia*). The genotypes differed significantly for all the characters studied and were grouped into six clusters based on the similarities of D² values. Considerable diversity within and between clusters were noted and it was observed that the characters like 100-seed weight, number of seed per fruit and yield per plant contributed maximum to divergence. Hence, selection of divergent parent based on these characters may be useful for heterosis breeding in bitter gourd. (**Parhi, Mishra and Tripathy, 1992**)

Studies on combining ability in bittergourd (*M. charantia*)

In 9 x 9 diallel cross (excluding reciprocals), 12 quantitative traits including total yield per plant were studied. The mean square for GCA were larger than those for SCA in all the characters studied indicating a strong tendency of transmitting the higher grain from parents to off springs. The estimated components of variance for SCA (Var. Sij) were larger than those for GCA (Var Gj). This indicated that the superior performance of F₁ hybrids showing high SCA was largely due to epistatic interaction. Parents Green long, Coimbatore Long, Gadabeta and Priya were the best general combiners for yield per plant, fruit weight and fruit size. The F₁ hybrids Coimbatore Long x Gadabeta, Nakhara Local x Green Long and Green Long x Thusi were the best specific combiners for yield per plant in order of merit. (**Mishra and Mishra, 1993**)

Genetic variability in pumpkin

The study was conducted with 19 genotypes, consisting of most of the local types collected from different places of Orissa and few improved cultivars from outside the state with an objective to observe the genetic variability in pumpkin. The result of the study revealed significant difference among the genotypes for all the 12 characters studied. The yield/plant, number of fruits /plant, fruit length and weight and duration of female flower showed higher GCV, PCV, heritability and genetic advance. Genotypic and phenotypic co-relation coefficients showed that number of fruits/plant as well as fruit weight had positive significant correlation with yield/ plant. Path coefficient analysis of various quantitative characters revealed that duration of female flower, fruit number and fruit weight had maximum direct effects on fruit yield of pumpkin. Cultivars such as Bhubaneswar-8, Cuttack local and Bhubaneswar-10 showed good performance. (**Sahu and Mishra, 1993**)

Heterosis and combining ability in bitter gourd

An experiment was conducted during rainy seasons (*Kharif*) of 1989 and 1990 to study the heterosis and combining ability for fruit characters in bitter gourd

(*M. charantia*) in a 9 x 9 parental diallel cross (excluding reciprocal). Both additive and non-additive gene actions were involved in the character expression of number of fruits/plant, fruit length, fruit breadth, fruit weight and yield in bitter gourd along with appreciable heterosis. Coimbatore Long was a good general combiner for all the characters. Hybrids with high effect of specific combining ability involved at least 1 of the parents with high general combining ability. (**Mishra and Mishra, 1994**)

Correlation and path-coefficient studies in bitter gourd

Correlation and path coefficient studies were conducted with thirteen genotypes of bitter gourd. Positively significant correlations of yield/plant with fruit weight, fruit length, number of seeds per fruit, vine length and days to first harvest indicated that simultaneous improvement can be made if selection is made for any one of the correlated characters. Path analysis revealed that revealed that fruit breadth, days to opening first male and female flower, vine length and number of seeds per fruit had maximum positive direct effect on yield in bitter gourd. The characters like fruit weight and fruit length though have significant positive correlation with yield exhibited low direct effect. Besides direct selection for yield, indirect selection through number of seeds per fruit and fruit weight would prove worth for further improvement in yield of bitter gourd. (**Parhi and Mishra, 1995**)

Diallel analysis for variability in bitter gourd (*M. charantia*)

Diallel analysis of 36 F₁ hybrid of bitter gourd involving 9 parents (excluding reciprocals) for 8 quantitative characters indicated frequent occurrence of dominant alleles for inheritance of the characters studied. Both additive and non-additive gene actions were involved in the character expression. Unequal distribution of genes at loci showing dominance was common in the parental population, indicating the interplay of partial dominance and dominance in character expression. Presence of dominance and complementary type of gene action along with low narrow sense heritability for yield indicates that heterosis breeding would be more advantageous to get higher fruit yield in bitter gourd. (**Mishra and Mishra, 1998**)

2. CROP PRODUCTION

Chemical Regulation of sex expression in relation to growth and yield in cucumber

Cucumber Cv. Long green was treated with MH (100,200 and 400 ppm), Cycocel (500,1000 & 2000 ppm) & TIBA (25,50, & 100 ppm) at 2 to 3 and 4 to 5 leaf stage. Application of 100 ppm TIBA decreased the length of vines (43.5 cm against 227.25 cm in Control) increased the number of branches/plant (6.0 against 4.0 in control) induced the development of pistillate flowers at the lowest node (4.0 against 11.0 in control) and reduced the ratio of pistillate to staminate flowers(1:2.23 against 1:15.52 in control).However, the maximum yield of fruits (110.5 g/plant) was recorded at 1000 ppm CCC, as against 294.5 gm in control (**Pradhan and Mishra, 1968**).

Studies on rooting response, subsequent growth and development of pointed gourd (*Tricosanthes dioca* Roub.)

Foliar application of IAA,IBA,B995,GA3 and NAA each at 0,10,100 and 1000 ppm were tried in pointed gourd.76% success was recorded with B-995 (100 ppm) in case of vine cuttings, IAA (10 ppm),NAA (1000 ppm), GA (1000 ppm),IBA (100 ppm) showed retarding effects on vine cuttings B995 (10 ppm), GA (100 ppm),NAA (10 ppm) decreased the success rate in swollen roots. IAA and NAA are more effective (Das and Das,1971).

Studied on the effect of Growth regulators on vegetative growth, sex expression and yield of cucumber (*Cucumis sativus* L.) and water melon (*Citrullus vulgaris* Schard)

B-9, cycocel and ethereal were sprayed at 2-3 true leaf stage and 5-6 leaf stage. Allthe three chemical found to increase the basal diameter, no of branches and caused early branching in cucumber and water melon. With highest doses of the three chemicals, more number of pistillate flowers were produced and the first pistillate flower appeared on the lowest and medium doses of chemicals respectively.B-9(1000ppm) recorded maximum fruit yield in both the cases (Panigrahi and Mishra, 1973).

Effect of nitrogen and growth substances on growth, fruit set, development and quality of pumpkin (*Cucurbita moschata* var. *vaidyabati*) Ridge gourd (*Luffa acutangula* var *satputia*)

Planofix (1, 2 cc/lt), Ethrel (100,200 ppm) and Alar-85 (100 & 200 ppm) were sprayed. Three levels of nitrogen (0, 20, 40 kg/ha) were applied. Growth regulators reduced the length of the plant but nitrogen increased it. Ethrel (200 ppm) increased the number of leaves, induced early flowering and reduced the total number of flower per plant. Nitrogen (40 kg) increased the number of leaves, delayed flowering by 10 days increased the no of flowers. Ethrel 200 ppm and nitrogen 20 kg produced maximum number of fruits (Swain and Das, 1973).

Effects of growth regulators on growth, sex expression and yield of pumpkin (*cucurbita maxima* Duch) and musk melon (*Cucumis melo* L.)

Two foliar sprays (2 to 3 and 4 to 5 leaf stage) of four growth regulators viz., Ethrel (100,200,400 ppm),B9 (250,500,1000 ppm),CCC (500,1000,1500,2000 ppm) and hadacidin (125,250,500 ppm) were tried in pumpkin and muskmelon. Cycocel and ethrel significantly induced dwarfness in pumpkin and muskmelon. But ethrel (400 ppm) proved to be superior in production of pistillate flowers, altering the sex ratio and increasing yield in both the crops. Ethrel at 400 ppm resulted in complete femaleness for a period of 15 to 20 days. The same treatment also recorded the highest yield of 213.01 q/ha in pumpkin and 214.63 q/ha in muskmelon. However, ethrel showed toxic effect at its highest (400 ppm) dose on both the crops, whereas cycocel proved toxic above 1500 ppm concentration in muskmelon (Prusty and Mishra,1978).

Studies on the effect of some trace elements and growth regulators on growth, sex expression and yield of bottle gourd. (*Lagenaria sicearia* Standl)

Bottle gourd plants were subject to 15 treatments along with a control. The results revealed that 200 ppm of Ethrel and 10 ppm of Morphactin were best for producing sturdy and dwarf vines. Among the trace elements, Mo showed better response in inducing pistillate flowers, number of fruits per plant and finally yield per plant. Ethrel can boost the yield of Bottle gourd during summer (**Sarangi and Mishra, 1980**).

Studies on the effect of growth substances on growth, sex expression and yield of pumpkin.

The experiment was carried out to study the effect of growth substances (ethrel and morphactin) on the growth, sex expression and yield of pumpkin. The results clearly indicated that the plants treated with ethrel (400 ppm) came to flowering at the earliest. However ethrel at 300 ppm recorded maximum fruit yield followed by morphactin at 20 ppm (**Mallik and Mishra, 1985**).

Integrated nutrient management in bottle gourd

Pooled data revealed that application of full dose of recommended NPK (50:30:50 kg/ha) in Bottle gourd resulted in maximum fruit yield (330.19 q/ha) with C:B ratio of 1:3.92, followed by combined application of FYM @ 10 t/ha + half dose of recommended NPK (309.07q/ha, 1:3.05, respectively) (**Nandi, Beura and Pandey, 2013**).

3. CROP PROTECTION

Integrated disease management of downy mildew in bitter gourd

The incidence of downy mildew of bitter gourd was low in bower system of planting as compared to non-bower planting. The disease was effectively managed by seed treatment with ridomil MZ 0.25 % + three times removal of lower infected leaves in the morning and spraying of mancozeb 0.25 % in the afternoon on bower system recorded 92.24% disease control over control with maximum cost benefit ratio 8.64 (**Beura, 2012**).

Integrated disease management of powdery mildew in pumpkin

The powdery mildew disease of pumpkin can effectively be managed by spraying with the fungicide tridemorph (calixin) 0.1 % which recorded lowest mean disease incidence (PDI-3.8%) corresponding to maximum fruit yield of 202.1 q/ha. The same treatment also registered 92.34% disease control, 52.41% yield increase over control and cost benefit ratio of 1:5.62 (**Beura, 2012**).

Future thrusts:

1. Collection, Evaluation, Maintenance and documentation of local germplasm of spinegourd, pointed gourd, cucumber, pumpkin and bitter gourd.

2. Standardization of agro techniques for commercial production as well as for export purpose for important cucurbits like bitter gourd, cucumber and pointed gourd in the state.
3. To develop Integrated Nutrient Management, Integrated Pest Management and Integrated Disease Management.
4. To standardize trellis system during rainy season particularly for bitter gourd and cucumber.
5. Effort should be made to recommend suitable varieties and F_1 hybrids of watermelon, pumpkin which can exploit its full potential under the vast sandy riverbed cultivation in the state.
6. Steps should be taken for proper marketing of the produce with minimum post-harvest loss and maximum benefits to the farmers. (Market links)
7. Steps should be taken to select varieties which can suit the requirements of value addition and processing industry particularly crop like pumpkin, bitter gourd, cucumber and ash gourd.
8. To identify various varieties of cucurbits which can be fitted the crop rotation as well as to contingent plan during adverse situation.
9. Emphasis should be given for protected cultivation of cucumber, pointed gourd etc.



Indigenous cucurbits: Present status and future prospects

Prakash S. Naik and Sudhakar Pandey

Indian Institute of Vegetable Research

P.B. No. 01, P.O. Jakhini (Shahanshahpur) Varanasi 221 305, India

1. Introduction

Cucurbits are vegetable crops belonging to family Cucurbitaceae, which primarily comprised species consumed as food worldwide. The family consists of about 118 genera and 825 species. Although most of them originated in Old World, many species originated in the New World and at least seven genera in both hemispheres of the globe. There is tremendous genetic diversity within the family, and the range of adaptation for cucurbit species varies from tropical and subtropical regions, arid deserts to temperate regions. A number of cucurbits are indigenous to India (Table 1). These crops are grown in summer and rainy season in northern and eastern part, while throughout the year in southern part of India. In India, cucurbits are cultivated in several commercial cropping systems and also as popular kitchen garden crops. Cucurbits have been ranked as excellent, very good and good on world's healthiest food ranking scale. Because of their high water and lower caloric content, they deliver more nutrients per calorie—an outstanding health benefit. The neutraceutical industry looks at Indian cucurbits particularly bitter gourd as a potential health capsule without any side effects. These indigenous cucurbits are consumed in various forms i.e., salad (cucumber, gherkins, longmelon), sweet (ash gourd, pointed gourd), pickles (gherkins & cucumber) and culinary purpose. By adoption of modern production technologies such as improved varieties/hybrids, IPM, proper training of farmers and better marketing opportunities, production and utilization of indigenous cucurbits have improved significantly.

Table 1: List of indigenous cucurbits

English name	Hindi name	Botanical name	Origin	Chromos -ome No. (2n)
Cucumber	<i>Khira</i>	<i>Cucumis sativus</i> L.	India	14
Bitter gourd	<i>Karela</i>	<i>Momordica charantia</i> L.	Indo-Burma	22
Pointed gourd	<i>Parwal</i>	<i>Trichosanthes dioica</i> Roxb.	India	22
Snake gourd	<i>Chichinda</i>	<i>Trichosanthes cucumerina</i> L.	India	22
Ivy gourd	<i>Kundru</i>	<i>C. grandis</i> (L.) Voigt.	India	24

Long melon	<i>Kakri</i>	<i>Cucumis melo L. var. utilissimus</i>	India	24
Snap melon	<i>Phoot</i>	<i>Cucumis melo L. var. momordica</i>	India	24
Round melon	<i>Tinda</i>	<i>Praecitrullus fistulosuos</i> (Stock.) Pang.	Indo-Burma (India)	24
Ash gourd	<i>Petha</i>	<i>Benincasa hispida</i> (Thunb.) Cogn.	South East Asia	24
Ridge gourd	<i>Kali Tori</i>	<i>Luffa acutangula</i> (L.) Roxb.	India	26
Sponge gourd	<i>Ghia Tori</i>	<i>Luffa cylindrica</i> (L.) M. J. Roem.	India	26
Hermaphrodite ridge gourd	<i>Satputita</i>	<i>Luffa hermaphroditia</i>	India	26
Sweet gourd	<i>Cochinchin</i> <i>Gourd</i>	<i>Momordica cochinchinensis</i> (Lour.) Spreng.	South East Asia	28

1. Current status of the cucurbits database

In India, the database on vegetables is published as Indian Horticulture Database by National Horticulture Board (NHB), New Delhi. NHB covers mostly commercial crops like potato, onion, tomato, brinjal, cruciferous vegetables, peas, okra etc., whereas no data on cucurbits is available with NHB. The data on cucurbits of India are given by FAO only in 4 major groups (Table 2). Cucurbits share about 4.06% of the total vegetable production in India and according to FAO estimates, it is cultivated on about 0.61 million ha with the productivity of 13.11 t/ha (FAO, 2012). According to an estimate, India will need to produce 300 million tonnes of vegetables by 2050 to meet the requirement of increasing population. Indigenous cucurbits being a largest group of vegetables; provide better scope to enhance overall productivity and production of vegetable to meet the challenge.

Table 2: Area, production and productivity of major cucurbits of India

Crop	Area (000 ha)	Production (000 tonnes)	Productivity (tonnes/ha)
Cucumber	26.50	168.00	6.34
Pumpkin, squash, gourd	510.00	4900.00	9.61
Watermelon	28.50	400.00	14.04
Melons	44.50	1000.00	22.47
Total	609.50	6468.00	13.11

1. Indigenous cucurbits and diet diversification

With the changing life styles and dietary patterns, the consumers in India are becoming more health conscious and also want more vegetable diversification and a continuous supply. In cucurbits, generally fruits are eaten but in case of longmelon, pointed gourd tender leaves are also equally preferred. Cucurbit vegetables are purchased partly based on their nutritive values, appealing appearance and price. Product differentiation, including introduction of new types is still a key strategy for expanding sales in vegetable markets. For example, the introduction of new vegetables such as ivy gourd, longmelon, sweet gourd and hermaphrodite ridge gourd (*satputia*) in market has opened new opportunities for domestic producers. Table 3 indicates major states producing different types of cucurbits. To exploit important virtues of cucurbits, it is important to continue research, disseminate information regarding the nutritional benefits of these vegetables, develop new improved cucurbit cultivars, processed products, evaluate the economic opportunities and the market scope of these new products, and identify marketing trends and alternatives (Dias and Ryder, 2011). Providing customers with innovative combinations of products (pickles from cucumber, sweets & candy from ash gourd and pointed gourd, juice from ash gourd, chips & powder from bitter gourd) and services is the key to the processed vegetables. The growth rate in retail sales of processed vegetables in India over the past years has been tremendous. Most of the supply increase could be achieved through higher per-unit productivity and reduction in postharvest losses, but production also needs to be boosted in non-irrigated areas, and in home and village gardens in remote and tribal areas where consumption levels are particularly low.

Table3: Main states in India producing indigenous cucurbit crops

Crop	Major states
Cucumber	Bihar, Chhattisgarh, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Himachal Pradesh, Uttarakhand
Bitter gourd	Andhra Pradesh, Bihar, Chhattisgarh, Haryana, Jharkhand, Kerala, Karnataka, Madhya Pradesh, Maharashtra, Mizoram, Odisha, Tamil Nadu, Uttar Pradesh
Pointed gourd	Bihar, Chhattisgarh, Karnataka, Odisha, Tamil Nadu, Uttar Pradesh,
Snake gourd	Karnataka, Kerala, Mizoram,
Ivy or scarlet gourd	Chhattisgarh, Uttar Pradesh, Jharkhand, Bihar, West Bengal, Tamil Nadu
Longmelon	Andhra Pradesh, Chhattisgarh, Haryana, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand

Snapmelon	Uttar Pradesh, Rajasthan, Bihar, Punjab, Haryana
Roundmelon	Madhya Pradesh, Uttar Pradesh, Haryana, Punjab
Ash gourd	Uttar Pradesh, Bihar, Jharkhand, Karnataka, Kerala, Punjab, Tamil Nadu,
Ribbed or ridge gourd	Andhra Pradesh, Bihar, Chhattisgarh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh
Sponge gourd	Andhra Pradesh, Bihar, Chhattisgarh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, Uttar Pradesh
Hermaphrodite ridge gourd	Eastern part of Uttar Pradesh, Western part of Bihar
Sweet gourd	Uttar Pradesh, Odisha, Bihar, Meghalaya, Mizoram, Assam

1. Plant genetic resources

In India, ICAR institute and State Agriculture Universities are involved in collection, conservation and utilization of indigenous cucurbits (Table 4). Rich genetic diversity in wild and cultivated species of *Luffa*, *Momordica*, *Cucumis*, *Coccinia*, *Momordica* and *Trichosanthes* has been augmented. There are several cucurbits, which have adaptability to a particular region of India. The *Momordica cochinchinensis* to Tripura, Assam and West Bengal, and *Trichosanthes dioica* to Eastern Uttar Pradesh, Bihar and West Bengal. The Indian Institute of Vegetable Research is a National Active Germplasm Site for the systematic management and utilization of germplasm wealth of vegetable crops including indigenous cucurbits. The major activity includes collection, evaluation, maintenance and distribution of germplasm. Many of the cucurbit germplasm having unique characteristics have been registered with National Bureau of Plant Genetic Resources (NBPGR) (Table 5).

Table 4: Institutes/SAUs involved in the research activity in indigenous cucurbits

Crop	ICAR institute/SAU/CAU highly involved in research activity
Cucumber	IIVR, Varanasi, IIHR, Bangalore, IARI, New Delhi, HPKV, Palampur, MPKV, Rahuri, GBUAT, Pantnagar
Bitter gourd	IIVR, Varanasi, IIHR, Bangalore, IARI, New Delhi, PAU, Ludhiana, KAU, Vellanikkara, TNAU, Coimbatore, CSUAT, Kanpur
Pointed gourd	IIVR, Varanasi, BAU, Sabour, HARP, Ranchi, Kalyani, NDUAT, Faizabad, IGKV, Raipur

Snake gourd	KAU, Vellanikkara TNAU, Coimbatore
Ivy gourd	IIVR, Varanasi, IGKV, Raipur, CHES, Bhubaneswar, TNAU, Coimbatore, BAU, Sabour
Long melon	PAU, Ludhiana, IIVR, Varanasi, CIAH, Bikaner
Snap melon	IIVR, Varanasi, IARI, New Delhi, CIAH, Bikaner
Round melon	HAU, Hisar
Ash gourd	IIVR, Varanasi, IARI, New Delhi, KAU, Vellanikkara TNAU, Coimbatore, ICAR Research Complex, Barapani
Ridge gourd	IARI, New Delhi, IIHR, Bangalore, IIVR, Varanasi, AAU, Anand
Sponge gourd	AAU, Anand, IIHR, Bangalore, IIVR, Varanasi, HARP, Ranchi, RAU, Samastipur
Hermaphrodite ridge gourd	IIVR, Varanasi
Sweet gourd	IIVR, Varanasi, CHES, Bhubaneswar, ICAR Research Complex, Barapani

Table 5. Registered germplasm of cucurbits having some unique trait

Cucurbits	National germplasm identity No.	Registered trait
Pointed gourd	INGR-03035	Parthenocarpic fruits
Bitter gourd	INGR-03037	Gynoecious sex with high yield
Cucumber	INGR-98017	High yield and long fruit
	INGR-98018	Small fruit, drought and high temperature tolerant
<i>Cucumis callosus</i>	INGR-98013	High yield and drought tolerance
Round melon	INGR-99038	Tolerant to downy mildew and root rot wilt
Snap melon	INGR-98015	High yield and drought tolerance
	INGR-98016	High yield and drought tolerance
	INGR-07044	Downey mildew resistance
Sponge gourd	INGR-1015	Cluster bearing

Source: NBPGR, New Delhi (www.nbpgr.ernet.in)

Jing et al. (2012) fingerprinted 3312 cucumber accessions using SSR markers. The data revealed three distinct populations, largely corresponding to three geographic regions. Population 1 corresponded to germplasm from China, except for the unique semi-wild landraces found in Xishuangbanna in Southwest China and East Asia; population 2 to Europe, America, and Central and West Asia; and population 3 to India and Xishuangbanna. Admixtures were also detected, reflecting hybridization and migration events between the populations. The genetic background of the Indian germplasm is heterogeneous, indicating that the Indian cucumbers maintain a large proportion of the genetic diversity and that only a small fraction was introduced to other parts of the world. The variability among indigenous cucurbits needs proper conservation to check the genetic erosion (Table 6)

Table 6: Variability in cultivated indigenous cucurbits and genetic erosion in Indian region

Crop	Variability status	Genetic erosion status
Cucumber	Very high	High
Bitter gourd	Medium	Low
Pointed gourd	High	Low
Snake gourd	Medium	Medium
Ivy or scarlet gourd	Medium	Medium
Longmelon	Low	High
Snapmelon	High	High
Round melon	Low	Medium
Ash gourd	High	High
Ribbed or ridge gourd	Medium	Low
Sponge gourd	Low	Medium
Hermaphrodite ridge gourd	Medium	Medium
Sweet gourd	Medium	Low

Source: Srivastava (2007)

1. Varietal Development

The evaluation of indigenous and exotic germplasm introductions, and their hybridization resulted in the selection of 77 superior varieties of different cucurbits. Of these varieties, 'Kalyanpur Baramasi' of bitter gourd and 'Japanese Long Green' of cucumber continue to be among the popular varieties due to their high yield

potential and consumer's preference. As a result of multi-location testing under All India Coordinated Vegetable Improvement Project, 18 improved varieties in 5 indigenous cucurbits have been identified and recommended for cultivation and release in various agro-climatic regions of the country (Table 7) (Rai et al., 2004, Rai et al., 2007). Four indigenous cucurbits are not included in multilocation testing of AICRP-VC. Hence, varieties of these crops have been recommended by states of the respective Institute/University (Table 7).

Table 7. List of the open pollinated varieties/hybrids released in India.

Crop	National level	State /Institute level
OP Varieties		
Bitter gourd	Priya, RHRBG-4-1, KBG-16, PBIG-1	Coimbatore Long, Pusa Do Mausmi, Pusa Vishesh, Punjab-14, Kalyanpur Baramasi, CO-1, CO-2
Cucumber	Swarna Ageti (CHC-2), S. Sheetal (CH-20), Pant Khira-1 (PCUC-28)	Japanese Long Green, Straight-8, Pusa Uday, Himangi, Phule Subhangi, Swarna Poorna, Sheetal, CO-1, Pant Parthenocarpic Khira-1, Pant Parthenocarpic Khira-2
Ridge gourd	S. Manjari (CHRG-1), PRG-7, Arka sumeet (IIHR-7)	Swarna Uphar, Co-1, Co-2, PKM-1, Arka Sujat, Pusa Nasdar, Pusa Nutan, Punjab Sadabahar, Haritham, Hisar Kalitori, GJRGH-1, Gujarat Anand Ridge Gourd-1, Pant Torai-1
Sponge gourd	Pusa Chikni, CHSG-1, JSGL	Pusa Sneha, Pusa Supriya, PSG-9, Rajendra Nenua-1, Azad Torai-1, Azad Torai-2
Ash gourd	Kashi Ujwal, Kashi Surbhi, KAG-1, Pusa Ujjwal, PAG-72	Kashi Dhawal,
Pointed gourd	-	'Swarna Alaukik', 'Swarna Rekha', 'Rajendra Parwal-I', 'Rajendra Parwal-II', 'Narendra Parwal-260', 'Narendra Parwal-307', 'Narendra Parwal-604, Kashi Divya, Kashi Suphal
Ivy gourd	-	Indira Kundru-05, Indira Kundru-35, Co-1, Kashi Bharpoor
Longmelon	-	Arka Sheetal, Karnal Selection, Punjab Longmelon-1, Pant Kakri-1
Roundmelon	-	Arka Tinda, Hisar Tinda (HT-10)
Snapmelon	-	Pusa Shandar
Hybrids		
Cucumber	Pant Sankar Khira-1, PCUCH-3, Hybrid No.-	Pusa Sanyog, AAUC-1, AAUC-2

Indigenous cucurbits are highly susceptible to several biotic and abiotic stresses. Resistance sources are generally present in landraces and wild relatives. Resistance to downy mildew (*Pseudopernospora cubensis*) is reported in snapmelon (*Cucumis melo* var. *momordica*), resistance to fruit fly is reported in *Cucumis callosus*. Most of the resistant varieties in cucurbits have been developed by simple selection. Varieties of bitter gourd (MDU-1) and ridge gourd (PKM-1) have been developed through mutation breeding.

Pointed gourd, ivy gourd and sweet gourd are vegetatively propagated. Therefore, plants derived from a single clone are genetically identical and phenotypically uniform, and also heterozygosity is maintained through clonal propagation. The most important step in clonal selection is creation of variability by assemblage of wide range of clones from different sources. Seedless pointed gourd is selected from a population as clonal selection at IIVR, Varanasi.

1. Breeding trends in indigenous cucurbits

Breeding of cucurbits has to address and satisfy the needs of both the consumer and the grower. The general objectives for growers are good yield, disease and pest resistance, uniformity, and tolerance to abiotic stresses. Objectives for consumers are quality, appearance, shelf life, taste, and nutritional value. Quality in vegetable crops, in contrast to field crops, is often more important than yield. Thus, colour, appearance, taste, and shape are usually more important than productivity. For example in India, cucumber breeding programme is concentrated only on slicing cucumber with objective of high yield, quality and resistance. Breeding work on parthenocarpic cucumber (controlled by single dominant gene with many modifiers) with gynoecious sex expression is initiated at GBPAUT, Pantnagar and IIVR, Varanasi for protected cultivation. The major colour segment in cucumber is light green, green, dark green and creamy skin. Several varieties and hybrids have been developed in slicing cucumber for commercial cultivation.

In bitter gourd, fruit shape is main segment of variation. Four type of fruit shapes are found in bitter gourd i.e.; a) large fusiform fruits pointed at both end dominated with triangular tubercles, b) small spindle shape, c) cone shaped, length 9-12 cm with dark green rind having prominent tubercles and d) Chinese long fruited (30-60 cm) with smooth ridge, light green skin colour. Gynoecious line (INGR 03037) has been developed and efforts are being made to utilize this line for development of better F₁ hybrids. Fruit fly and potty viruses are becoming limiting factors for bitter gourd production. This invites initiation of a breeding programme to develop few resistant varieties/hybrids.

Considering the importance of ash gourd in diet as good source of nutrition, medicinal properties and importance in petha industry, it is need of the hour to develop new varieties with better traits. For petha preparation big size (10-15 kg) oval to cylindrical fruits are required, while for household consumption small cylindrical fruits (1-2 kg) without ash are in demand. Breeding for seedless, or fruits

with less seeds may be the focus of present research as seedless fruits are easy for processing in petha industry.

In ridge gourd and sponge gourd major emphasis should be given to develop small cylindrical fruits having sequential fruiting habit (bearing on each node). The hermaphrodite ridge gourd may be utilized for developing ridge gourd and sponge gourd with sequential fruiting genotypes. These cultivars should be resistance to downey mildew, powdery mildew and viruses.

Genetic improvement to increase levels of specific micronutrients has been pursued in longmelon. The yield and nutritional content of long melon has been increased significantly by exploiting intraspecific genetic variation of genetically diverse melons. Inbred long melon 'Punjab Long melon 1' (PLM1) was hybridized with five genetically diverse inbred melons: KP 7 (var. *momordica*), AM 72 (var. *acidulus*), 'Arya 1' (var. *chate*), 04-02 (var. *tibish*) and 'Punjab Wanga' (*Cucumis melo* var. *melo*). The parents and hybrids were evaluated at three locations for nine traits. Hybrids PLM1 x 04-02 and PLM1 x 'Punjab Wanga' exhibited significant heterosis for the number of marketable fruits per plant, ascorbic acid and carotenoid contents of marketable fruits (Pandey et al. 2010). Sanpmelon is available in the Indian markets for about five months in the rainy season and are utilized by poor and middle class consumers. Mineral and vitamin rich varieties would be important supplements to the nutritional needs of these consumers. Carotenoids in mature fruits of snapmelon accessions ranged from 34.7 to 308.2 mg/100 g. Ascorbic acid was more in the snapmelon landraces from northern India (up to 34.1 mg/100g) as compared to the accessions from eastern India (up to 19.4mg/100g) (Dhillon et al. 2012).

The germplasm of ivy gourd, sweet gourd, snake gourd, roundmelon and pointed gourd should be characterized properly and promising accessions should be recommended for cultivation. The availability of quality planting material is very important for popularization of ivy gourd, pointed gourd and sweet gourd as they are vegetatively propagated.

2. Advanced production technologies

Production of cucurbits can be maximized by using high yielding cultivars, early production through nursery management, protected cultivation, optimum use of fertilizers and insect pest management.

Nursery management

Direct sowing of cucurbit seeds in the field increases the cost of cultivation due to more seed rate, uneven germination and delays in fruiting. Nursery can be grown in 1-2 inch diameter pro-trays using sterile cocopit growing medium. These plug trays should be kept under poly or net house. Before sowing the seeds, the growing media should be watered and allowed to dry for 24 hrs. Solution of urea (4g/liter) is applied 2 times in a week to the growing seedlings. Usually seedlings will be ready for transplanting in 18-20 days after sowing. Hardening of seedlings under open sunlight should be done for 2-3 days before transplanting.

Use of mulch and fertigation

Healthy cucurbit crops are grown by using polythene mulch and drip irrigation. Fertilizers are given with help of drip irrigation. This insures uniform application of fertilizer and water near root biosphere. Critical stages when moisture stress is more critical are (a) at transplanting, b) early flowering stage and c) fruit development stage. Moisture stress at flowering stage results poor fruit set and bitterness of fruits in ridge gourd. Moisture stress during fruit development greatly reduced fruit size. Black polythene mulch should be used during winter season (low temperature) whereas reflective mulch is used during summer (high temperature). Reflective mulch also repels aphids and jassids. The use of mulch reduces the weed infestation; increase water and nutrient use efficiency and reduce fruit rotting. About 40-80% higher marketable yield has been reported in mulch and fertigation culture in cucurbits as compared to without much and drip irrigation.

Bower system for growing cucurbits and high density planting

Generally farmers grow cucurbits on ground in open field. Training of cucurbits on bower facilitates easy pest management, uniform fruit shape, colour, increase harvesting efficiency and yield. Since cucurbit crops are vine in nature, they bear more number of fruits for longer period on supporting structures. It has been observed that if vines are allowed on the ground, nearly 25-30% less yield has been recorded and 8-10% fruits become unmarketable due to misshaping and discoloration. The planting distance of cucurbits can be reduced and plant population per unit area increased by training of plants on bower system. Pruning of trained plants is essential to achieve a balance between vine growth and fruit set. In cucumber, single stem is allowed to grow with 2-3 fruiting branches, which increases the number of marketable fruits.

Use of pollinators

Honey bee is main pollination agent in cucurbits grown in protected or open field conditions. Generally 3 bee hives are required per acre in cucurbits for proper pollination. For better fruit formation, 81 bee visits per flowers are required. Farmers should use pesticides very judiciously and only if necessary, pesticides should be applied in the evening. In cucumber misshapen fruit are found due to lack of pollination. Increased fruit set (15-20%) has been recorded with the use of 3 bee hives per acre.

Protected cultivation of cucurbits

Protected cultivation is providing opportunities for improving productivity by reducing climatic extremes (temperature, rainfall, pest incursion) in hot and cool areas. The National Horticulture Board provides financial support for developing protected cultivation infrastructure. Although systems are expensive, yield increases

of up to 300 % for high value high quality produce offset costs (Hort WG, 2007). Walk-in tunnels (including low-cost structures) have been evaluated for off-season cucurbits and seedling production. Insect-proof houses are also being used to reduce pest levels, pesticide use and virus incursions. Parthenocarpic cucumber production under controlled condition gives very high yield with quality fruit.

3. Conclusion

The main goal of research on indigenous cucurbit crops in India is to improve productivity on sustainable basis. The breeding programme should shift towards development of biotic and abiotic resistant varieties/hybrids coupled with quality attributes. Cucurbit breeding strategy and targets are dependent on market trends. Successful breeder anticipates changes in the market by developing new cultivars that are ready to be released to the growers when their demand increases. The yield potential of cucurbits could be increased by adopting standard agro-techniques and plant protection measures. Considering growing concerns about residue free vegetables and export of fresh/canned vegetables, it has become imperative to shift to IPM-based plant protection measures. Research is urgently needed to resolve issues such as the development of drought tolerant varieties, management of crops under water deficits, dealing with increased salinity, and use of low quality water. In general, productivity is major criteria to get maximum return but like other vegetable crops, quality and availability of the produce during lean periods are also equally important to fetch better price in the markets. Therefore, development of hybrids/varieties with better adaptability under off-season should be undertaken. Further, in order to reduce cost of hybrid seeds, it would be appropriate to utilize the available genetic mechanisms for hybrid seed production. In this regard, development of high frequency pistillate/gynoecious lines is advocated. For developing multiple biotic stress resistant lines, validation of already available molecular markers with established linkages may be tested in order to examine their feasible use in breeding programmes for developing superior parental lines.

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Indian fruit flies in cucurbits : Significance and management

*Abraham Verghese**

National Bureau of Agriculturally Important Insects

Bangalore 560024, India

*<directornabaii@gmail.com>

Preamble and Distribution

The family Tephritidae consists of over 4000 species, of which nearly 700 species belong to Dacine fruit flies (Fletcher, 1987), of which 250 species are of economic importance. These are distributed widely in the temperate, sub-tropical, and tropical regions of the world (Christenson and Foote, 1960).

The first report on melon fruit flies was published by Bezzi (1913), who listed 39 species from India. *Bactrocera cucurbitae* belongs to the subgenus Zeugodacus Hendel, a group whose members have a strong preference for attacking Cucurbitaceae (White and Elson-Harris 1994). Fruit fly species which attack cucurbits are *Bactrocera cucurbitae*, *B. tau*, *B. caudatus*, *Dacus ciliatus*, *B. cucumis*, *B. cucuminatus*, *Anastrepha grandis*, *B. diversa*, *B. expandens*, *B. scutellaris*, *B. munda*, *B. scutellata*, *Dacus solomonensis*, *D. bivittatus*, *D. demmerezi*, *D. punctatofrons*, *D. frontalis*, *D. lounsburyii* and *D. vertebratua* (Cavalloro, 1983; Drew and Hooper, 1983; Munro, 1984; Fletcher, 1987).

The melon fly *Bactrocera cucurbitae* (Coquillett) is a major, highly polyphagous, agricultural pest abundant throughout the African continent, the islands of Indian Ocean, Asia (including India), New Guinea, the Mariana Islands and Hawaii. This species attacks more than 125 plants including commercial crops such as pumpkin, cantaloupe, watermelon, squash, gourd, cucumber, tomato, eggplant and bean as well as soft fruits such as mango, orange, papaya and peach. The melon fruit fly is distributed all over the world, but India is considered as its native home. It was discovered in Solomon Islands in 1984, and is now widespread in all the provinces, except Makira, Rennell-Bellona and Temotu (Eta, 1985). Although the economic importance of *B. cucurbitae* is well documented, its large-scale (*i.e.* inter-regional) patterns of genetic structuring are poorly known.

The proportions of inter-regional assignments and the higher values of genetic diversity in populations from Pakistan, India and Bangladesh suggest that *B. cucurbitae* originated in Central Asia and expanded its range to East Asia and Hawaii on one hand and to Africa and the islands of the Indian Ocean on the other. A number of outliers (10-19 specimens according to different clustering algorithms) show

high levels of admixture ($Q>0.70$) with populations from different regions and reveal complex patterns of inter-regional gene flow (Massimiliano *et al.*, 2010).

The melon fruit fly-biology, damage, quarantine, management

Amongst the above fruit flies, the Melon fruit fly, *Bactrocera cucurbitae* is a major threat to cucurbits (Shah *et al.*, 1948). The fruit fly attacks the ultimate economic part, i.e. fruits of the crop that alone can inflict yield loss in different cucurbitaceous vegetables ranging from 30- 100% depending upon cucurbit species and the season (Dhillon *et al.*, 2005a & b). For cucurbits, especially bitter gourd, *Momordica charantia* Linn., the melon fruit fly damage is the major limiting factor in obtaining good quality fruits and high yield (Srinivasan, 1959; Lall and Singh, 1969; Mote, 1975; Rabindranath and Pillai, 1986). It prefers young, green, and tender fruits for egg laying. The females lay the eggs 2 to 4 mm deep in the fruit pulp, and the maggots feed inside the developing fruits. At times, the eggs are also laid in the corolla of the flower, and the maggots feed on the flowers.

It also poses major threat to global trade, since many countries have invoked restrictions to minimize the risk of establishment of exotic species. Maggots feed inside the fruits, but at times, also feed on flowers, and stems. Generally, the females prefer to lay the eggs in soft tender fruit tissues by piercing them with the ovipositor. A watery fluid oozes from the puncture, which becomes slightly concave with seepage of fluid, and transforms into a brown resinous deposit. Sometimes pseudo-punctures (punctures without eggs) have also been observed on the fruit skin. This reduces the market value of the produce. In Hawaii, pumpkin and squash are heavily damaged even before fruit set.

The eggs are laid into unopened flowers, and the larvae successfully develop in the taproots, stems, and leaf stalks (Weems and Heppner, 2001). Miyatake *et al.* (1993) reported < 1% damage by pseudo-punctures by the sterile females in cucumber, sponge gourd and bitter gourd. After egg hatching, the maggots bore into the pulp tissue and make the feeding galleries. The fruit subsequently rots or becomes distorted. Young larvae leave the necrotic region and move to healthy tissue, where they often introduce various pathogens and hasten fruit decomposition.

Extent of crop loss

Bactrocera cucurbitae attacks different species of cucurbits, affecting internal and export markets (Vergheese *et al.*, 2005). The extent of losses varies between 30 to 100%, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89% (Lall and Singh, 1969; Narayanan and Batra, 1960; Rabindranath and Pillai, 1986). The melon fruit fly has been reported to infest 95% of bitter gourd fruits in Papua (New Guinea), and 90% snake gourd and 60 to 87% pumpkin fruits in Solomon Islands (Hollingsworth *et al.*, 1997). Singh *et al.* (2000) reported 31.27% damage on bitter gourd and 28.55% on watermelon in India.

In La Réunion, cucurbit crops suffer considerable damage due to fruit fly attacks. A complex of three species (The Melon fly, *Bactrocera cucurbitae*, The Ethiopian fly, *Dacus ciliatus*, and the Indian Ocean fruit fly, *Dacus demmerezi*) coexist in the island and can infest 16 different species of Cucurbitaceae. It seems that, in the complex of Dacini attacking cucurbits, the species do not have the same strategy regarding intraspecific competition. The larvae of *B. cucurbitae* are able to share resources and maintain a good survivorship finally giving more adults with low weight. Conversely, in *D. demmerezi* larval survivorship is decreased but the pupal weight of survivors remains high. Further studies will be needed on larval interspecific competition in this complex of fruit flies, in order to understand the performance of each species in situations of co-infestation (Kumar *et al.*, 2006).

Quarantine Importance

Tephritid fruit flies are the most destructive insect pests of horticultural crops worldwide. To prevent the invasion of exotic tephritids, many countries set strict regulation on the quarantine inspection for imported fruits and vegetables. A method for rapid identification of the species of intercepted pests, which are most at their larval or even egg stages, are required to enhance the efficiency and quality of quarantine inspection and service. Fruit fly pest risk analysis and pest free areas are vital in coming years to ensure sustained import/ export of vegetables. The import and export of infested plant material from one area or country to other non-infested places is the major mode of the spread of insect-pests. The spread of the melon fly can be blocked through tight quarantine and treatment of fruits at the import/export ports. Cold treatment at $1.1 \pm 0.6^\circ\text{C}$ for 12 days disinfested Hawaiian starfruit, *Averrhoa carambola*, of tephritid eggs and larvae (Armstrong *et al.*, 1995). Heat treatment of avocado fruits infested with eggs and larvae of *B. cucurbitae* for 40°C for 24 h reduced the estimated surviving population by 99.5 to 100% (Yang, 1994). Import controls carried out in airports in France since 1993 on tropical fruits have revealed the presence of 12 non-European and one European species of Tephritidae, (Bayart *et al.*, 1997).

Integrated Pest Management of Fruit Fly in Cucurbits

From 2001 to 2005 a major fruit fly management programme was initiated by ICAR in collaboration with Imperial College London, UK, under DFID grant with IIHR, Bangalore as the national coordinating centre. Management of fruit fly studies was conducted at Bhubaneshwar (Orissa), Trivandrum and Trichur (Kerala), Ponda (Goa), Anand and S. K. Nagar (Gujarat) and Varanasi (U.P.). The crops included diverse cucurbits like bitter gourd, small gourd, ridge gourd, pumpkins etc. The strategy was to develop residue free and economically viable integrated pest management for the fruit fly, *B. cucurbitae*. These strategies included evaluation of different baits like jaggery, banana pulp, visual colour traps and male annihilation technique (MAT)

through the use of cue-lure traps. The study involved standardizing the quantum of baits/MAT and their frequency to obtain desired controls.

Field sanitation

The most effective method in melon fruit fly management uses primary component-field sanitation. To break the reproduction cycle and population increase, growers need to remove all unharvested fruits or vegetables from a field by completely burying them deep into the soil. Burying damaged fruits 0.46 m deep in the soil prevents adult fly eclosion and reduces

Bait Application Technique (BAT)

This consists of bait sprays sprayed as splashes in non-target areas like underside of leaves avoiding the fruits. The baits include jaggery or squashed ripe banana or a mixture of these two at 10% concentration in water. For every litre of this mixture, 2-5ml of malathion 50EC is to be added. These are applied in 200spots/Ha at a rate of 40ml/spot (approximately 8L/Ha) to the undersides of leaves with sprayers or splash with a fine brush. Fruit flies attracted to these spots are killed. Here the fruits are free of spray and will be free of all residues (Vergheese, 2005).

The attraction of food baits to melon flies was assessed in laboratory cages. 100g of banana was significantly superior to a mixture of 50g banana with 50g jaggery, 100ml of protein hydrolysate and 100g of jaggery. Eight food baits and mixtures to attract and kill melonflies were assessed in two experiments in the laboratory. Banana was significantly superior to pumpkin though not to molasses. Field traps containing protein hydrolysate at different strengths caught more flies, with a larger dose, in a smaller ratio than that between concentrations, indicating a diminishing return to increases in concentration. In the protection of bitter gourd from fruit flies in field plots, jaggery significantly superior to protein hydrolysate and to banana; this ranking was consistent among data obtained as trap catches, reductions in infestation and yield. As the assessment value proceeded from the assessment of insect abundance to the assessment of economic returns, the p-values declined (Satpathy *et al.*, 2005).

For the sustainable adoption of technology, it must be at least the equal of any existing, convenient and established competitor, and IPM of Tephritisid fruit flies must be the equal of conventional high volume cover sprays if it is to be acceptable to farmers. Two experiments assessed the protection of cucurbits from melon flies by cue-lure male annihilation (MAT) and by bait application (BAT) in a 2x2 factorial design, In snake gourd near Thiruvananthapuram, inferred percentage reductions in infestation, relative to the untreated controls, were significant, of 51% by MAT, 61% by BAT and -80% by interaction between them. In pumpkin near Sardarkrushinagar, MAT and BAT obtained improvements of, respectively, 29% and 26% in harvested mass and 45% and 44% in percentage infestation; interaction between MAT and BAT was negative but not significant. The two treatments exerted

significant control individually but in combination they interacted to obtain a control "less than the sum of its parts (Stonehouse *et al.*, 2005).

Coloured spheres

Fruit flies often locate oviposition sites in fruit by sight, using shape and colour to orient themselves, and are known to be attracted to spheres of different colours, presumed to resemble fruits, as sites for either oviposition, feeding or courting mates. It is assumed that some colours are more attractive than others, presumed to resemble fruits at more attractive stages of development, and that this attraction may be exploited to create or augment points of attraction for control purposes. Whether some colours are preferred more strongly than others may give some indication of at which stage or stages host fruit are most vulnerable, and of whether colour and shape may be a useful component of controls based on attraction. Some role in monitoring, if not control, may be played by coloured traps which mimic ripe fruit. *B. correcta* is more readily attracted to yellow and orange targets than to red, green, white, violet or blue.

The attraction of tephritid fruit flies (mostly of melon flies) to coloured plastic balls was assessed in fields in different parts of India. Near Thrissur melon fruit flies were attracted to yellow, green and red; those near Thiruvananthapuram were attracted to yellow significantly more than green and pink; those near Bhubaneswar were attracted to green and pink but not orange; those near Anand were attracted to pink, red and green. *Bactrocera* species near Sardarkrushinagar were attracted significantly more to balls of increasing redness along the scale yellow-orange-red. Flies near Thiruvananthapuram were attracted, in rank order, most to orange, then yellow, violet, green, red and blue, and to balls of 8cm diameter significantly more than of 6cm, but numbers attracted to balls at 1.35m height did not significantly differ from those at 1.2m. Overall, flies were attracted to an increasing scale of redness with a peak at yellow/orange rather than red itself (Jiji *et al.*, 2005).

Monitoring and control with parapheromone lures/cue-lure traps.

The principal of this particular technique is the denial of resources needed for laying by female flies such as protein food (protein bait control) or parapheromone lures that eliminate males. There is a positive correlation between cue-lure trap catches and weather conditions such as minimum temperature, rainfall, and minimum humidity. The sex attractant cue-lure traps are more effective than the food attractant tephritis lure traps for monitoring the *B. cucurbitae* in bitter gourd.

Male Annihilation Technique (MAT)

This consists of the use of cue-lure soaked in plywood (5x5cm squares of plywood of approximately 1.2cm thickness), soaked for 48 hours in a solution of 6:4:1 V:V:V ethanol:cue-lure:malathion (Stonehouse *et al.*, 2005). These blocks are hung from pandals or stakes, at a density of 10/Ha. These are installed just below the

level of the crop leaf canopy. Male fruit flies are attracted to these and killed. These individual blocks can also be placed in bottles with vents (Verghese *et al.*, 2005).

Additional Recommendations for the Use of MAT Blocks

Once prepared, blocks have short shelf lives, and fresh blocks should be made for each deployment. Blocks deteriorate in rain, particularly if steady and prolonged, and benefit by being protected from it (for example in bottle traps see Verghese *et al.*, 2006).

In MAT blocks, higher-volatility insecticides such as DDVP may obtain more effective kill than lower-volatility insecticides such as malathion, but may have lower persistence, particularly in the rain. MAT blocks do not need to be in traps to work, though these often give information and reassurance to farmers. If traps are used, catch may be enhanced if these are coloured yellow. Blocks may be made of concentrated ingredients dripped onto absorbent composite substrates such as "straw board" or "soft board" or soaked into harder woods with a solvent. Plywood is a suitable wood in the latter case; ethanol and ether as solvents are better than most practical alternatives.

For making lure-and-insecticide MAT blocks, the liquid may be soaked in ethanol solvent into plywood or dripped onto strawboard or soft board. As long as labour resources and weather permit, water traps, while of low persistence, are very effective at providing a "short sharp burst" of killing power, and may be the most cost-effective use of lure if traps can be maintained and replaced sufficiently frequently.

Ethanol can be dispensed with by applying 1ml of cue-lure and 1ml of dichlorovos (insecticide) directly to the plywood before placement in field. These recommendations are also relevant to gherkins, which is a major export crop of India.

Biological control

There are no reports on the successful use of bio-control agents against the melon fruit fly. Srinivasan (1994) reported *Opius fletcheri* Silv. to be a dominant parasitoid of *B. cucurbitae*, but the efficacy of this parasitoid has not been tested under field conditions in India. The parasitization of *B. cucurbitae* by *O. fletcheri* has been reported to vary from 0.2 to 1.9% in *M. charantia* fields in Honolulu at Hawaii (Wong *et al.*, 1989). Similar level of parasitization (<3%) was also reported from northern India by Nishida (1963). However, Willard (1920), Newell *et al.* (1952), and Nishida (1955) have reported parasitization at levels of 80, 44, and 37%, respectively, from Hawaii. Thus, there is a need to reevaluate the parasitization potential of *O. fletcheri* before its exploitation as biocontrol agent for the management of *B. cucurbitae*. More recently, a new parasitoid, *Fopius arisanus* has also been included in the IPM program of *B. cucurbitae* at Hawaii (Wood, 2001).

A Mexican strain of the nematode, *Steinernema carpocapsae* Weiser (*Neoaplectana carpocapsae*), has been reported to cause 0 to 86% mortality to melon fruit fly after an exposure of 6 days to 5000 to 5,000,000 nematodes/cup in the laboratory, and an average of 87.1% mortality under field conditions when applied at 500 infective juveniles/cm² soil (Lindgren, 1990). Sinha (1997) reported that culture filtrate of the fungus, *Rhizoctonia solani* Kuhn, to be an effective bio-agent against *B. cucurbitae* larvae. While, the fungus, *Gliocladium virens* Origen, has been reported to be an effective against *B. cucurbitae* (Sinha and Singh 1998). Culture filtrates of the fungi *R. solani*, *Trichoderma viridae* Pers., and *G. virens* affected the oviposition and development of *B. cucurbitae* adversely (Sinha and Saxena, 1999).

Chemical Control

Chemical control of the melon fruit fly is relatively ineffective. However, insecticides such as malathion, dichlorvos, phosphamidon, and endosulfan are moderately effective against the melon fly (Agarwal *et al.*, 1987). Bhatnagar and Yadava (1992) reported malathion (0.5%) to be more effective than carbaryl (0.2%) and quinalphos (0.2%) on bottle gourd, sponge gourd, and ridge gourd. The application of molasses + malathion (Limithion 50 EC) and water in the ratio of 1: 0.1: 100 provides good control of melon fly. Application of either 0.05% fenthion or 0.1% carbaryl at 50% appearance of male flowers, and again at 3 days after fertilization is helpful in reducing the melon fly damage. Gupta and Verma (1982) reported that fenitrothion (0.025%) in combination with protein hydrolysate (0.25%) reduced fruit fly damage to 8.7 % as compared to 43.3 % damage in untreated control. Application of carbofuran granules at 1.5 kg a.i./ ha at the time of sowing, vining, and flowering gave 83.35% protection to bitter gourd against *B. cucurbitae* (Thomas and Jacob, 1990). Dicrotophos (at 600g a.i.) and trichlorfon (at 1920g a.i./ ha) has been found to give good control of *B. cucurbitae* in muskmelon (Chughtai and Baloch, 1988).

Formathion is more effective than trichlorfon (Talpur *et al.*, 1994). Diflubenzuron has also been reported to be effective in controlling the melon fly (Mishra and Singh, 1999). Reddy (1997) reported triazophos to be the most effective insecticide against this pest on bitter gourd. Highest yield and lowest damage were observed in pumpkin when treated with carbofuran at 1.5 kg a.i./ ha at 15 days after germination (Borah, 1998). An extract of *Acorus calamus* (0.15%) reduced the adult longevity from 119.2 days to 26.6 days when fed continuously with sugar mixed with extract (at 1 ml/g sugar) (Nair and Thomas, 1999). Neem oil (1.2 %) and neem cake (4.0 %) have also been reported to be as effective as dichlorvos (0.2 %), (Ranganath *et al.*, 1997).

Sterile insect technique

In this technique, sterile males are released in the fields for mating with the wild females. Sterilization is accomplished through irradiation, chemo-sterilization, or by genetic manipulation. In sterile insect programs the terms 'sterility' or sterile

insect' refer to the transmission of dominant lethal mutations that kill the progeny. The females either do not lay eggs or lay sterile eggs. The use of male-sterile and male annihilation techniques has successfully eradicated the melon fly from Japan for over 24 years (Shiga, 1992; Liu, 1993). However, the suppression of *B. cucurbitae* reproduction through male annihilation with cue-lure may be problematic.

Matsui *et al* (1990) reported that no wild tephritids were caught with cue-lure traps after intensification of distribution of cue-lure strings, but the mating rates of mature females did not decrease as compared to those on control islands. Conventional sterilization based on ionizing radiation causes chromosome fragmentation without centromeres, where the chromosome fragments will not be transmitted correctly to the progeny, and can have adverse effects on viability and sperm quality, resulting in reduced competitiveness of sterilized individuals (Hooper and Katiyar, 1971).

Dacus ciliatus and Bactrocera cucurbitae complex

Among the cucurbit fruit fly species, melon fly, *Bactrocera cucurbitae* and lesser pumpkin fruit fly, *Dacus ciliatus* Loew are the most destructive insect pests on cucurbits. Pumpkin fruit fly is one of the several fruit flies found in Africa and Asia, which could become serious pests throughout in large part of Africa and India. Although Pumpkin fruit fly is not serious as the melon fly, in areas where both species occur, heavy infestations of cucurbits by *D. ciliatus* have been reported in Egypt and in (Shah *et al.*, 1948). The lesser pumpkin fly, *D. ciliatus* infests a few cucurbits in the Asian sub-continent and parts of Africa. While extensive work on seasonality, infestation percent, host preference, attraction to parapheromone has been reported for melon fly, very little is reported for another fruit fly species *D. ciliatus*. South Africa. Several studies have been devoted to their bio ecology and management (Deguine *et al.*, 2012). *D. ciliatus* was first reported in India in 1914 and was first collected from Upper-Egypt, in February 1953. *D. ciliatus* was trapped with *B. cucurbitae* in cue lure traps but in small numbers (Kumar *et al.*, 2006).

In India, this species generally infests a large number of melons and wild cucurbits to a relatively lesser extent though, in patches serious damage is reported (Bhatia 1939, Viraktamath *et. al.*, 2003). *D. ciliatus* is relatively smaller than *B. cucurbitae*, orange in with facial spots. Costal band in the wing is apically expanded to form a small apical spot and a basal oblique spot. Abdomen has two black spots especially in females (White and Elson-Harris, 1992). The proportion of *D. ciliatus* compared to *B. cucurbitae* was high in north Karnataka. The mean percentage of *B. cucurbitae* and *D. ciliatus* was 96.68% and 3.32% in infested cucurbit fruits from south Karnataka whereas 46.35% and 53.64 % in north Karnataka (Subhash *et al.*, 2013). *Dacus ciliatus* adults are not attracted to parapheromones like cue lure or methyl eugenol (White and Elson- Harris, 1994). Therefore it's difficult to monitor them through cue lure traps and alternative control measure has to be taken.

Fruit fly research in some parts of the world focuses on the quarantine risk that the alien species may pose and the means of eradicating outbreaks if they occur. However, in South Asia, especially India a major concern is the optimum control of established integrated pest management (IPM). The control of fruit flies is particularly difficult on small orchard and vegetable plots because of the constant immigration of flies from nearby areas. Fruit fly IPM in India, as in most parts of the world, requires an area-wide approach, organizing groups of growers to reduce the overall fly population in the respective area. Well organized fruit and vegetable growers can achieve high levels of control with practices that are safe to themselves and the consumers of their produce, and obtain good yields of healthy commodity and consequently realize higher prices. The principle of area-wide control requires appropriate measures like male annihilation traps (MAT) along with sanitation and baits. Transfer of technology based on the outcome of an ICAR-DFID programme (IMFFI) showed that fruit fly control in cucurbits was a success story, conducted at multilocations in the country and at several other countries.

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ACKNOWLEDGEMENT: I THANK P. D KAMALA JAYANTHI, SUBHASH B KANDAKOOR, M. A RASHMI, T. N. SHIVANANDA, N. K. KRISHNA KUMAR and H. S. SINGH FOR THEIR SUPPORT AND INPUTS.



Plant genetic resources of cucurbitaceous crops of Indian sub-continent: Potential thrust areas for their scientific management

I.S. Bish

Principal Scientist & Professor

*National Bureau of Plant Genetic Resources,
Pusa Campus, New Delhi-110 012*

Cucurbitaceae or the gourd family comprises approximately 125 genera and 960 species, grown around the tropics and in temperate areas. The family perhaps has the highest number and percentage of species consumed as human food both in Old and New World. The Indian Gene Centre has rich genetic diversity in ridge gourd (*Luffaa cutangula*), bottle gourd (*Lagenaria ciceraria*), bitter gourd (*Momordic acharantia*), ash gourd (*Benincasa hispida*), snake gourd (*Trichosanthes anguina*), pointed gourd (*T. dioica*), pumpkin (*Cucurbita* spp.) and round gourd (*Praecitrullus vulgaris*). Areas with rich genetic diversity, in India, are north-eastern region, north-western Himalayas, Western and Eastern Ghats and Indo-Gangetic plains. The tribal dominated areas in every production systems are invariably rich in genetic diversity of cucurbitaceous crops. In north-eastern region, maximum diversity occurs in *Cucurbita* spp., ash gourd and bottle gourd. Diversity in *Luffa* is more concentrated in eastern peninsular tract. *Cucumis melo* and round gourd are more confined to Indo-Gangetic plains. Diversity in pointed gourd (parwal) is confined to eastern parts of Indo-Gangetic plains i.e. parts of Uttar Pradesh, Bihar and West Bengal. The domesticated, semi-domesticated and wild forms of several cucurbitaceous species with greater diversity across Indian sub-continent include *Lagenaria ciceraria* (of African origin but domesticated throughout India), *Coccinia cordifolia*, *Luffacylindrica*, *L. acutangula*, *L. echinata*, *L. graveolens*, *L. hermaphrodita*, *Momordica balsamina*, *M. dioica*, *M. cochinchinensis*, *Citrullus colocynthes*, *Trichosanthes* spp. (21 species reported in India), *Cucumis sativus* ssp. *sativus*; *C. sativus* ssp. *hardwickii*, *C. trigonus*, *C. hystrix*, etc.

Cucurbits are grown in varied agro-ecological conditions in Indian sub-continent and are rich source of biological water, and are easily digestible. Cucurbits are rich source of nutrition such as carbohydrates, proteins, vitamin A and C, calcium, lycopene, phosphorus and potassium, beside several ethno-medicinal uses. Bitter gourd is rich in vitamin C and iron, pumpkin is rich in carotene, *kakrol* (*M. dioica*) in protein and cho-cho (*Sehium edule*, a native of Mexico and Guatamala but grown in north-eastern region of India since centuries) rich in calcium. Some cucurbits also have other uses, mature fruits of bottle gourds are used for making vessels and musical

instruments; fibrous material of *Luffa* is used for scouring and packaging, beside ornamental and medicinal uses.

Extent of diversity in cucurbitaceous vegetables in India

Of the 125 genera and 960 species in the world, 36 genera and 100 species are reported to occur in India including 38 endemic species. Majority of the cucurbit species are of tropical origin and are distributed across Indian sub-continent, eastern Himalayas, north-eastern region, Gangetic plains, Indus plains, western peninsular tract, western Himalayas and eastern peninsular tract. Apart from cultivated forms, enormous diversity occurs in wild and semi-domesticated forms. The semi-domesticated and wild species often contribute significantly in subsistence of local inhabitants particularly in tribal and marginal areas. Beside source of specific adaptations, these species play an important role in local culture and livelihood as sources of nutrition and ethno-medicinal uses. Species of global importance grown in India with substantial diversity include, *Citrillus lanatus* and *Cucumis melo* (of African origin); *Cucumis sativus* (of Indian origin); *Cucurbita maxima* (South American origin); *Cucurbita moschata*, *C. mixta* and *C. pepo* (of Central Mexican origin).

Cucurbit species with regional and local importance grown in Indian subcontinent include *Benincasa hispida*, *Citrullus colocynthis*, *Coccinia indica* syn. *C. grandis*, *Lagenaria siceraria*, *Luffa acutangula*, *L. cylindrica*, *Momordica charantia*, *M. cochinchinensis*, *M. dioica*, *Praecitrullus fistulosus*, *Sechium edule*, *Trichosanthes anguina* syn. *T. Cucumerina* and *T. dioica*.

The genus *Cucumis* has more than 30 species of which Cucumber (*C. sativus*) and melon (*C. melo*) are economically important. *Cucumis sativus* is reported to have originated in India where its close wild relatives and progenitor species occur. Of these *Cucumis sativus* and to some extent *C. callosus* are cultivated whereas *C. sativus* ssp. *hardwickii* (progenitor of cultivated *C. sativus* ssp. *sativus*), *C. hystrix*, *C. prophetorum* and *C. setosus* are wild. Melons are considered to be of African origin where wild species with same chromosome number occur but its domestication may have occurred simultaneously in East Asia and Southeast Asia including India. Seven horticulturally important groups of melons have been reported to occur based on fruit characteristics and uses.

Plant genetic resources (PGR) management of cucurbitaceous crops: NBPGR efforts

The National Bureau of Plant genetic Resources (NBPGR), New Delhi and its regional stations located in different agro-ecological regions of the country have made sincere efforts to augment the diversity occurring in different cultivated cucurbit species and available diversity have been collected. The native diversity was also enriched with introductions from exotic sources as well including some wild species. Efforts have been made by NBPGR and other commodity institutions to characterize and evaluate the assembled germplasm and a number of promising

accessions have been identified. A few genetic stocks with unique traits have also been registered. The National Genabank at NBPGR currently holds about 5000 accessions of different cucurbitaceous crops, bottle gourd, ridge gourd, sponge gourd, bitter gourd, cucumber, musk melon, snap melon, water melon, round melon, pumpkin, ash gourd, pointed gourd, etc.) which are freely accessible to all bonafide researchers of the NARS.

Status of germplasm utilization

The cultivars in different cucurbit species have been the result of either direct selection in germplasm, recombination breeding or through induced mutations to some extent. In some crops hybrids have also been developed. Though the unadapted germplasm and wild relatives of crop species have been reported to be a source of resistance/tolerance against biotic and abiotic stresses, yet their use in crop improvement have often been limited.

Thrust areas for scientific interventions

The thrust areas for scientific management of diversity of cucurbitaceous crops can be as follows:

- Most of the cucurbitaceous crops in diverse agroecologies are grown and consumed by the native farmers using their traditional wisdom. A complete inventory of the existing diversity, the traditional culture and wisdom, and value addition prospects needs to be documented together with nutritional composition of the landrace diversity.
- *Several of the cucurbitaceous vegetables of local importance are grown as backyard or kitchen garden crops and are underutilized. Traditional backyard gardens, in all agro-ecologies, have a great diversity of these crops, well adapted to local microclimates and requiring a minimum of purchased inputs. The backyard gardens supplement the diet with vitamin-rich vegetables and energy-rich vegetable staples in traditional farming. The backyard garden may become the principal source of household food and income during periods of stress. Experiences of gardening projects around the world illustrate the importance of building on indigenous knowledge; reducing biophysical, agronomic and economic constraints; integrating nutrition education and social marketing in gardening projects; promoting the economic benefits of gardening; understanding the roles of women and children; and working towards an integrated food security strategy. It may also be easily linked to on-farm conservation of crop diversity.*
- The NBPGR has adequately addressed the *ex situ* conservation of genetic diversity in National Genebank for different cucurbitaceous crops. More recently, *in situ* (on-farm) conservation has emerged and is increasingly recognized as an important complement to *ex situ* conservation. On-farm conservation involves farmers' continued cultivation and management of a

diverse set of crop populations in the agroecosystem where the crop evolved, or in secondary centres of diversity. This conservation strategy depends on farmers' active participation because it acts on farmers' reasons and incentives to maintain diversity, but it is not necessarily clear how to support farmers' efforts to maintain diversity on their farms. There is a need to identify and implement appropriate interventions based on a thorough understanding of factors that threaten crop diversity on-farm and farmers' reasons for abandoning rather than maintaining diversity. In an advanced, industrialized economy, and in the absence of special government programmes, it may be argued that landrace diversity will only be grown when they have unique qualities that urban consumers or export markets value, and only if these same qualities cannot be easily transferred into modern varieties. Where genetic diversity is considered to be important in a target area but farmers are revealed to have few social, cultural or market-based incentives to maintain it, then specific publicly funded initiatives may be needed. Economists generally believe that these forms of interventions are more "costly" to society than market-based incentives.

- As interest is increasing worldwide in on-farm conservation as a component of a strategy to conserve crop genetic resources, this may require outside support to small-scale farmers in areas of crop diversity. It has been argued that crop diversity maintained by farming households results from the interplay between a demand and a supply for this diversity. Interventions to support on farm conservation can be conceptualized by the way they influence these two factors. Demand interventions should increase the value of crop diversity for farmers or decrease the farm-level opportunity costs of maintaining it, while supply interventions should decrease the costs of accessing diversity.
- Cucurbit species of global or regional importance can be grown as component of crop diversification in cropping patterns. Reversal of post-harvest losses and value addition in food products can also be integrated. Cucurbits hold promise as supplementary food for the common masses.
- Basic researches on domestication, systematics, and molecular phylogeny of native taxa, particularly *Cucumis* complex, are another potential area requiring adequate scientific interventions.
- *In situ* (on-farm) management of crop wild relatives needs to be addressed and pre-breeding initiatives needs to be strengthened. Many of the wild taxa in *Cucumis* complex and other native taxa has great potential to be exploited for many of the desired yield related traits and sources of biotic and abiotic stresses. Biotechnological tools can be used to overcome crossability barriers for enhanced utilization of wild gene pool.
- Registration of unique diversity, awarding/rewarding the custodian farmers and other measures of IPR protection of native farmers will also add value to cucurbit species diversity occurring in production landscapes.



Post-Harvest management and value addition of cucurbits

C.K. Narayana and D.V. Sudhakar Rao

Division of Post-Harvest Technology

Indian Institute of Horticultural Technology, Bangalore-560 089.

Cucurbits are found throughout the tropics and subtropics of Africa, southeastern Asia, and the Americas. Though history of their domestication and usage are poorly documented, references made in literature indicate existence of one or the other of them in all the regions. Anecdotes indicate use of cucurbits as medicine prescribed during the period of Indo-Aryan civilization. In Ayurveda, the vedic text, Ash gourd (Winter Melon) is referred to as 'Kushmandam' and there are many medicinal formulations prescribed for various ailments either as prophylactic or therapeutic treatment. It is also used in various spiritual practices (pujas) in Hindu religious ceremonies (Atharva-veda). Over the period of time with criss-crossing of travellers all over the world, today we find large number of cucurbits grown all over the country.

Cucurbitaceous vegetables consists of cucumbers, melons (musk melon and water melon), Cantaloupes, pumpkin, squashes (summer squash, winter squash), gourds (bitter gourd, bottle gourd, ridge gourd, sponge gourd, snake gourd, spine gourd, pointed gourd, Ivy gourd, ash gourd), chow chow, etc., and are highly perishable as they contain more than 90% water. They are also easily prone to mechanical damage during harvesting, handling, transportation and marketing leading to post harvest losses. The major post-harvest problem in these crops is moisture loss resulting in shrivelling, wilting and desiccation contributing to economic losses.

Generally cucurbit fruits mature fast after fruit set. Fruits reach edible maturity within a week to 10 days in case of cucumber (pickling type), long melon, bitter gourd, summer squash, tinda. In ridge gourd, sponge gourd, bottle gourd, snake gourd, pointed gourd, etc. picking of fruits can be done in about 15-20 days after fruit set. However, fruits like musk melon and water melon require 30 to 40 days to reach full maturity.

Cucumber: Cucumber fruit should be harvested at an immature stage, near full size but before the seeds are fully enlarged and become hard. The two main external indices of harvest maturity are fruit size and skin colour. The main internal indices of harvest maturity are seed development, locular jelly formation, and flesh texture. Fresh market slicing cucumbers should be at least 15 cm (6 in) long and firm to the touch. The peel should be a uniform dark to light green colour when harvested. The fruit should not be allowed to turn yellow as they are over-mature at this stage, and fruits turn leathery in texture and bitter in taste. At proper harvest maturity, a jelly-like material will be formed in the seed cavity.

The optimum temperature for storage of cucumber is 10-13°C with 90-95% RH. Storage life of cucumber is generally less than 14 days as visual and sensory quality deteriorates rapidly. Shrivelling, yellowing, and decay are likely to increase following storage beyond two weeks, especially after removal to ambient conditions. Cucumbers are susceptible to chilling injury below a storage temperature of 10°C.

Cucumbers in India are mostly grown for salad purpose, while gherkins are exported. Gherkins used for pickling, are harvested when they attain 2 ½" length, are relatively small in size and thin skinned with light green coloured prominent warts or spines. Cucumbers / gherkins are processed mainly as pickles (dill herbs). Cucumber pickles are made in different ways like naturally fermented pickles, brined cucumber pickles, canned pickles, refrigerated dills, fresh cucumber pickles and processed pickles (sweet, sour, relishes, etc.).

Fermentation of cucumbers brined in 2.5 to 5.0 per cent salt solution for few days results in acidic products which can be preserved by refrigeration storage or by pasteurization. In refrigerated type pickles, lightly fermented cucumbers are covered with a brine containing spices and 0.1 per cent sodium benzoate and stored at 4-7°C. Salt-stock cucumbers are obtained by brining initially at 5 per cent sodium chloride and increasing brine strength gradually to 15-16 percent during the course of 6-7 weeks. Salt extracts sugar into brine which is converted into lactic acid by the action of microorganisms.

Watermelon: Water melon is mainly used as a dessert fruit. Fruits are harvested at full ripe stage based on the harvest indices like i). Dull or muffled sound when the fruit is tapped, ii) yellowing of the spot touching the ground iii) withering of tendril at the fruit axils, and iv) fruit rind at the blossom end, yielding to thumb pressure. Melons should be cut and not pulled from the vines to prevent mechanical damage to the stem end. Care should be taken to leave as much attached peduncle as possible. While transporting enough cushioning should be provided to prevent mechanical damage. The optimum storage temperature recommended for water melon is 13-15°C. High RH is not required for water melon as they do not readily lose moisture and RH in the range of 80-85% may be satisfactory. The water melon remain edible for about 2 months at moderate temperatures, but the quality will be low beyond 2 weeks.

Milk shake, ready-to-serve juice and cut fruit cubes are value added forms in which watermelon is consumed. It can be blended with other juices and is a good hydrant during summer. Possibility of making value added products like nectar, squash, jam and pickle have been reported. Candied rind is another product possible from watermelon which can be used for making confectionary and baked products. It can also be used for making animal feed.

Muskmelon: Harvesting at the proper stage of maturity is important for good quality in musk melons as flavor and texture of the fruit is best at full maturity.

As fruit approaches maturity a light abscission crack develops at the joint where the fruit is attached to the stem. When this crack completely encircles the joint, the melon slips out easily from the vine with a little pressure or jerk or if not it will remain separated the next day (Full slip stage).

Melon varieties that do not slip have to be picked on basis of colour, where green stripes on skin begin to turn yellow. In netted cantaloupes, changes in netting and skin colour are the external signs of maturity. The net becomes elevated and hard as the melon matures. The skin colour changes from green to yellow and netting becomes pale or dirty white. TSS and sucrose content increase as the fruit ripens and minimum TSS should be 10 per cent with 1 to 2 kg firmness.

Use of calcium chelate treatment was reported to doubled the shelf life of whole honeydew melon. Exogenous polyamines retarded chlorophyll loss in muskmelon by reducing the hydrolytic activities acting on chloroplast thylakoid membranes.

As muskmelon are harvested on attaining full maturity and the pulp is soft, it is consumed more as a dessert than in any other form. Muskmelon juice & milk shakes are also popular in several parts. Cube of muskmelon are used in ice-cream and fruit custards. Some value added products from muskmelon like nectar, squash, jam, enzyme clarified juice have been developed at University of Agricultural Sciences, Bangalore.

Bitter gourd: The bitter gourd is considered to be mature when tips of blossom end of fruits is turning white. Fruits of bitter gourd should not turn yellow before harvest and seeds should not get hardened before harvesting. Bitter gourds are usually picked while still tender, as such fruits are generally preferred by consumers. Picking should be done every 2-3 days as bitter gourd fruits mature fast. If harvesting is delayed the seed coat becomes hard and the seed kernel becomes well developed. Fruits start turning yellow 18-20 days from anthesis and become unfit for consumption.

At ambient temperature the bitter gourd is reported to have a shelf life of 3 days. Yellowing of bitter gourd fruits could be prevented and storage life extended to 14 days by post-harvest treatment with 1-MCP followed by packaging in polypropylene (100 gauge) bags and storing at 12°C. Waxing of bitter gourd along with S OPP (1%) has been reported to increase its shelf life besides modified atmospheric storage using polymeric films at 15°C.

Bitter gourd is considered to be of high therapeutic value due to its bitter principle and recommended for management of diabetes. It contains several bioactive glycosides (including momordin, charantin, charantosides, goyaglycoside, momordicosides) and other terpenoids. In western countries it is mostly processed in canned form for catering to the needs of armed forces. In India several value added products are made, mostly in traditional cuisine. Stuffed bitter gourd is a delicacy,

where the fruits are slit open to remove the seeds and pulp and then stuffed with spiced fillings and baked. Dehydrated bitter gourd rings are popular in almost every household. The fruits are sliced into rings and dipped in salt solution or smeared with salt to dehydrate before drying in sun. The dried product is stored and used as fryums as and when needed. Bitter gourd pickle is very popular in northern part of India and is also used in mixed vegetable pickles. With the rise in diabetics, bitter gourd juice is gaining popularity as a health drink. A recipe for fresh ready-to-serve bitter gourd juice was standardized at MPKV, Rahuri (Maharashtra) which contained 15ml fresh bitter gourd juice, 15g sugar, 0.29g citric acid and 76ml water. Blending of bitter gourd juice with lemon and herbs have been successfully attempted with the product having a shelf life of 60 days. Spiced and deep fried bitter gourd rings are part of Indian snack and savory industry.

Bottle gourd: Bottle gourd is being used in India for very long time. Dried shell of over-mature bottle gourd were used as containers for carrying water, wine/liquor and storage of seeds and other commodities in India and several African countries. Bottle gourd has high medicinal value and hence used in some Ayurvedic medicines. Bottle gourd is a good source of vitamin- B- complex and ascorbic acid. It is rich in pectin and also contains various saponins, fatty oils and alcohols. It has a cooling effect on the human body and is also useful in prevention of constipation.

Bottle gourd takes about 12-15 days after fruit set to reach the marketable stage. Fruits should be picked every 3-4 days when still tender and attain sufficient size. The tenderness can be checked by piercing the finger nail on the fruit surface with little pubescence persisting on the skin. The seeds inside should be soft when the fruit is cut transversely. Care in postharvest handling is very important in bottle gourd, as the skin is smooth and soft.

The bottle gourd is wrapped in news paper or in banana leaves during its marketing in some parts of country to avoid bruising while handling and marketing. Packaging studies have shown that by wrapping in newspaper or polymeric films the shelf life of bottle gourd could be extended upto 6 days under ambient condition. Some varieties (Summer Long Green & Rainy Green) have shown a storage potential upto 12 days at 25°C and upto 24 days at 5°C. However, the optimum temperature recommended for cold storage of bottle gourd is 8-9°C, where it can be stored for 4-6 weeks.

In India several delicacies are prepared traditionally using bottle gourd. It is processed into Doodhi Halva, Kofta and jelly. Bottle gourd dessert (*Lauki Kheer*) is popularly consumed during fasting. Good quality tutti-frutti can be prepared by slow syruping process and it has a storage life of over 3 months.

Snake gourd: Snake gourd is widely distributed in India and southeast Asia and tropical Australia. While harvesting, it has to be hand picked when still tender and

about one quarter to one third their full size. If over mature it becomes lighter in weight, fibrous and hard and on ripening jelly surrounding the seed become yellow or red. Postharvest shelf life is 2-3 days at ambient temperature and if dipped in wax emulsion containing S OPP for 30-60 seconds, it could be stored upto about 2 weeks. Snake gourd is mainly used as a vegetable in Indian cuisine like curries, kootu, porial, etc. In Nigeria the pulp of ripe snake gourd is used as a substitute of tomato and it is also used as purgative in Nigerian traditional medical practice.

Sponge and Ridge gourds: Sponge gourd (*Luffa cylindrica*) and Ridge gourd (*Luffa acutangula*) are native to Asia and Africa and are widely cultivated in India for vegetable purpose. Tender fruits are harvested before the inside flesh turns fibrous. Ridge and sponge gourd fruits attain marketable maturity about 5-7 days after anthesis and fruits are harvested when they are still immature. Delay in harvesting causes fruits to become more fibrous and are unfit for consumption. Fruits harvested at marketable stage can be stored for 3-4 days. Ridge gourd has slightly longer shelf life compared to sponge gourd. Both these gourds are mainly used for cooking purpose in various kinds of Indian dishes. Traditionally *Luffa* was popular for products like bathing sponge, scrubber pads, pillows and mattresses and also for cleaning utensils. The shelf life of ridge gourd was reported to improve by dipping the fruits in benzyl adenine (BA) at 50 ppm.

Ivy gourd: Ivy gourd (*Coccinia grandis*, L. or *Coccinia indica*) has a spread from Africa to Asia including India, Philippines, China, Indonesia, Malaysia, Thailand, Vietnam, eastern Papua, New Guinea and Northern Territories of Australia. It is extensively cultivated in India and is known by different names like Kundru (Punjai), Tindori (Hindi), Dondakaya (Telugu & Kannada), Kovai or Kovakkai (Malayalam & Tamil) etc. Ivy plant was used in Indian traditional medicine as a household remedy for various diseases, including biliary disorders, anorexia, cough, diabetic wounds, and hepatic disorders. The tender fruits come to first harvest in about 70 days after planting. Fruits should be harvested when they are tender before the seeds mature. The over mature fruits ripen faster and the pulp turns red. Preservation by canning was attempted at CFTRI, Mysore. It has very low glycaemic index and is preferred by diabetics.

Pointed gourd: Pointed gourd (*Trichosanthes dioica*) is a perennial vegetable cultivated in many parts of India. The fruits come to harvest 80-90 days after planting. The harvesting has to be done once in 2-3 days when the fruits are still immature and green, and before seeds become hard. It has slightly longer shelf life than coccinia (Kundru) and is mainly used as a vegetable. Among the processed products, candied pointed gourd is popular in northern India. Stuffed and baked parval is a delicacy served during weddings and parties.

Ash gourd: Ash gourd or wax gourd or white gourd is known as 'Petha kaddu', in India. Mature ash gourd comes to harvest 30-40 days after fruit set. The fruits at maturity show white waxy coating on the surface. The surface of ash gourd undergo suberization during storage. It has a good storage life of over 6 months at low temperature (13-15°C). Sometimes quashes are subjected to a curing or drying for a period of 2 weeks at 24-30°C with good air circulation to harden the shell before storing at low temperature.

One of the most popular processed product of ash gourd is 'Petha' (*popular as Agra Petha*) or preserve. It is made by boiling the cubes or pieces of peeled ash gourd fruit in sugar syrup of 30°Brix which is gradually increased to 70°Brix at 24 hours interval till it becomes tender and transparent. Ash gourd is the main ingredient in 'Kusumanda Lehyam" used in Ayurvedic system of medicine as a rejuvenating agent and in the treatment of nervous disorders. Fruit has also been used to treat disorders of the GI tract, respiratory tract, urinary tract and diabetes mellitus. It is known to render protection against histamine induced bronchospasm.

Pumpkins: Pumpkin (*Cucurbita moschata*) though native to Northern America is widely cultivated in India. The fruits are harvested at full mature stage after attaining full size and seeds mature. Vine start drying at full maturity and fruits will have greenish yellow skin. Pumpkins are usually cut from the vines with a portion of stem attached. Similar to ash gourd, pumpkins are also subjected to curing or drying with good air circulation to allow the shell to harden. Pumpkins are quite storable under ambient conditions. However, at a low temperature of 12-15°C and 70-75% RH it can be stored upto 24-36 weeks.

Among the vegetables, pumpkins are very good source of beta carotene. It is used in various kinds of dishes in Indian cuisine, the style and recipe of which varies from one region to another. It is widely used as a substitute for tomato in vegetable sauce making in small processing industries.

Pumpkins seeds are roasted (referred to as seed kernel) and eaten for its nutrition. The endosperm of pumpkin seed is reported to contain high amount of zinc and different forms of vitamin E (alpha, gamma, delta forms of tocopherol). Pumpkin seed oil is reported to be used as a cooking medium in Australia.

A. General Guidelines for harvesting and handling

Fruits like cucumber, tinda and summer squash have to be harvested every alternative day or once in two days while multiple harvests of bitter gourd, bottle gourd, pointed gourd and chow-chow have to be carried out once in a week or 5-6 days.

- Harvesting has to be done generally by hand plucking or using harvesting aides.

- Fruits should be clipped close to the base so as to leave no stem to cause damage in handling and transport
- Avoid any physical injury during harvesting.
- Place the harvested fruits carefully in the clean containers preferably plastic crates to avoid mechanical injuries and for easy handling.
- Avoid harvesting during the hot period and during or immediately after rains
- Harvesting should be done during the coolest time of the day, preferably in the morning to avoid the effect of high temp.
- The harvested produce should be kept under shade to avoid direct exposure to sunlight. Sunburn can cause fruit injury leading to a leathery, tough area on rind, usually at the stem end.

B. Cleaning and washing

Any soil attached to the produce should be removed at the time of harvest either manually by rubbing the fruit surface with a soft damp cloth or cotton gloves. Washing the fruit is more efficient if the cucumbers are particularly dirty, or if the quantity of fruit is large. Washing can be done by submerging the produce in a large wash tank and the surface can be rubbed clean by hand or with a soft brush. The wash water should be clean and properly sanitized to reduce the potential spread of disease. Sodium hypochlorite (household bleach) is commonly used since it is an inexpensive and readily available disinfectant. It is effective against decay organisms when added to the wash water at a concentration of 150 ppm and the water is maintained at a pH of 6.5. The wash water in the tank should be changed when necessary and filled with clean water with 150 ppm hypochlorous acid. After cleaning, the fruit is generally placed on a soft mesh or wire table to dry before sorting and grading.

C. Sorting and grading

Sorting is done to remove immature, over mature, mis-shapen, damaged, bruised ones. Grading is primarily based on uniform shape, firmness and a dark green skin colour. Bitter gourds that are green, 20-25cm long having short neck are preferred in the international market. Similarly bottle gourds that are light green, straight, cylindrical, 25-30cm long are more preferred by consumers. Additional quality indices are size, freedom from growth or handling defects, freedom from decay, and absence of yellowing. Long, moderately slender, tender, straight and dark green coloured cucumbers fetch better price. Pumpkins are not generally graded or some grading is done based on size shape and colour.

D. Packing

Cucurbits should be packed in strong, well-ventilated containers. Durable plastic crates are highly useful and appropriate for the domestic market. Mesh sacks

should not be used as they provide little protection to the fruit. Cucurbits for export should be packed in strong well ventilated corrugated fiberboard cartons with minimum test strength of 275 psi. Carton size varies depending on market destination, but typically contains 25 kg of fruit. If cucumbers are packed in smaller cartons they are sold by count, with 24-count being a popular size. Water loss can be effectively prevented by packing cucumbers in ventilated films.

Modified Atmosphere Packaging: The storage life of cucumber could be extended to 3 weeks at 10°C by MA packing in flexible films with retention of freshness and tenderness and without any shriveling.

Individual Shrink-wrapping: It is a form of modified atmosphere packaging wherein a flexible film is shrunk tightly (using hot air tunnel) around each piece of produce that acts as a barrier for water loss. By this packaging method, the storage life of cucumber was extended to 24 days at 10°C and 10 days at room temperature with less than 1% weight loss.

E. Storage: The optimum storage temperature reported for different cucurbits is given in the following table.

Optimum cold storage conditions & storage life of vegetables

Vegetable	Temp (°C)	Relative humidity (%)	Storage life (Weeks)
Cucumber	10-11	90-95	2
Chow chow	12-13	90-95	3
Gourd, bottle	8-9	85-90	4-6
Gourd, snake	18-20	85-90	2
Muskmelon, Honey dew	7-8	85	4-5
Pumpkin	12-15	70-75	24-36
Squash	12-15	70-75	8-24
Watermelon	12-15	80-90	2

Zero energy cool chamber

The zero energy cool chambers (ZECC), utilizing the principle of evaporative cooling is reported to maintain relatively low temperature and high humidity compared to ambient conditions that is highly suitable for short term storage of many cucurbits.

Post-Harvest Decay of Cucurbits

Several pathogens can cause post-harvest decay of cucurbits, including fungi such as *Sclerotinia sclerotiorum*, *Penicillium* spp., *Rhizoctonia solani*, *Fusarium* spp,

Phytophthora spp., *Pythium* spp., and *Rhizopus* spp. and several bacteria such as *Erwinia carotovora* subsp. *carotovora* and *E. chrysanthemi*. Fungal pathogens will cause a soft, watery black decay of fruit, cottony white fungal growth on the surface of water-soaked lesions, or water-soaked light brown to tan lesions, among others. Bacterial rots are accompanied by a soft decay of the fleshy rot tissues with a watery or slimy consistency as the rot progresses.

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Potential, scope and status of Cucurbits in TamilNadu

Dr S Anbu

*Former Dean, Horticulture College and Research Institute,
Periyakulam, Tamil nadu*

Tamil Nadu the Southernmost State of India enjoys a conducive climate for the growth of many floras and especially the Cucurbits and its wild relatives. Tamil Nadu is the only state which has both Western and Eastern Ghats which meets at Nilgris. Tamil Nadu is situated between 80.5°E to 76.5°E longitude and with a latitude of 8°N -13.0°N, typically a tropical state with vast germplasm of numerous kinds of crops.

Eastern rain shadow part of the Western Ghats beginning in Coimbatore district and end in Kanyakumari district (Nilgris (Uthagamandalam), Anamalai (Valparai,Cinchona), Pulney hills (Kodaikkanal), Pothigai hills (courtallam), Agastyar Malai (Papanasam), Mundanthurai Cardamom hills , Kalakaddu, Mahendragiri and Pechiparai (Kanyakumari) are important hot spots in Western Ghats. UNESCO World Heritage Committee classified this area as world heritage site – Hottest Hot Spots. Aadipattam (June-July) is the main season for all crops and especially for Cucurbits. Tolbert (2000) and Morrison (2000) refers this fact more specifically to cucumbers grown during 14th to 17th century A.D. The temperature range is between 21°C -38°C (now around 40°C) and the average is 30°C. The rainfall is between 630mm-1900mm and the average is around 750mm (now there is a reduction), received in 44-50 days with most of the rainfall and rainy days falls during October, November and December.

Tamil Nadu is one of the urbanized State of India, but with more than half of the population in early 21st century continued to live in rural areas. This is one of the reasons for the main activity –agriculture, preserving the traditional crops and introduction of recently released cultivars in vegetable crops.

Black cotton soils (Vertisols) of Tamil Nadu are a source of livelihood for small farmers with Cucumber and Athalaikkai (*Momordica tuberosa*. Cogn. (Roxb)/ *Luffa tuberosa* (Roxb), while in sloppy hilly terrain Pazhupagal–*Momordica dioca* Roxb X.Wild) forms the part of livelihood for tribal people and farmers at foot hills. The plant scientists and taxonomists Susanne S. Runner and Arun K Pandey (2014) observed more Cucurbitaceous specious in Tamil Nadu from very early time. *Cucumis ritchili* (1767) *Trichosanthes khasiane* (1793) *Momordica* spp., *Benincase hispida*, *Citrullus colocynthes*, *Coccinia grandis* (1834) the cultivation in Tamil Nadu.

Cucurbits are under commercial cultivation with the introduction of newer varieties of TNAU, IIHR and IARI. Many of the native gourds form a part of the germplasm in TNAU, IIHR, IARI and NBPGRI also. Cucurbit also forms a part in the early establishment of Bananas and perennial foot crops. In the Kitchen garden also Cucurbits play a major role.

In addition to the use as raw vegetable Cucurbits are rich source of vitamins, iron, phosphorous and other minerals, play a major part in the folk medicine (Esp. Bitter gourd and its wild relatives) and the traditional home medicine for the ailments like diabetes, ulcers and one of the folk medicine induce abortion in the early time.

Athalakkai, *Momordica tuberosa* cogn (Roxb), (*Momordica cymbalaria*/ *Luffa tuberosa* Roxb) is found to be in cultivation from very early times in Tamil Nadu. Athalakkai has higher amounts of minerals such as Ca, K, Na and Vit 'C' than bitter gourd with higher crude fiber. The fruits have a good shelf life and tender seeds. It is also highly useful against rheumatism, ulcers, skin diseases and diarrhoea, besides a good anti- oxidant. The tubers are used against diabetes mellitus and act as antiovulatory agent also.

The dioecious *Momordica dioica* Roxb, *Momordica balsamina* (Wall., Non l.). The Pazhupagal in Tamil was seen in Deccan area and hilly slopes of Tamil Nadu (The Viralimalai (Manaparai), Alagar kovil (Madurai), Varusa Nadu (Theni) and the Sathuragiri Mahalingam (Watrap) hills. Early references by Joseph Potton de Turnfort (1706) observed the presence of *Luffa aegyptiaca* (*L. acutangula*) in Tamil Nadu (Peerankai) - adjoining states (Kerala, Karnataka, Andhra Pradesh) and Maharashtra.

Luffa hermaphrodita was referred by Singh and Bhandari (2000) in early time in Tamil Nadu near Achankovil Valley of Tamil Nadu. Some of the similar plants were observed in Pitchavaram, Muthupet, Ramnad, Pulicat, Kazhuveli parts of Tamil Nadu.

Abraham (2003) referred the plants in Sangam Literature (2nd Century BC to 2nd Century AD). Morrisan (2006) quotes presence of *Luffa aegyptiaca* in the districts of Chinglepet, Dharmapuri, Vellore and Tirunelveli (Banks of River Thamiraparani in Tamil Nadu and in other states ie. Karnataka, Andhra Pradesh during Neolithic stage- Iron age (1000-500 BC).

Cucumis callosus Cogn, the bitter Cucumber Cogn. Were observed from very early time in rain shadow areas of Western Ghats (the Eastern side), have the field resistance to a host of pest and diseases. Early crossing work in Annamalai University found the resistance particularly for fruit fly in musk melon.

Presence of *Cucumis dipsaceus* Enrenbh ex.Spach (Maruthamalai foot hills of Western Ghats - Coimbatore), *Cucumis trigonus* Roxb (Kovanur in Coimbatore dist, Alangulam in Tirunelveli dist) name as Kumittikkaai/Thummattikaai, *Cucumis prophetarum* L., *Cucumis prophetarum* subsp. *dissectus*, *C.figarex* var. *dissectus* Naudin, *C. figarex* var *echinophorus* Naudin were reported in very early time.

Cucumis sativus and *Cucumis melo* and their numerous wild relatives are found from ancient times in Tamil Nadu. *Cucumis sativus*, the garden Cucumber was under cultivation for more than 3000 years in south India esp. in Tamil Nadu. The gherkin (*Cucumis anguna*) is a crop of recent commercial cultivation. *Cucumis prophetarum* is also seen under cultivation for many years. *Cirrullus lanatus* (*Citrullus fistulosus*, *C.vulgaris*, *Paracitrullus fistulosus*) Stock., the Tinda was also in cultivation (the variety Annamali Pudhama-released from Annamalai university).



Cucurbits can change the economy of tribal farmers of Odisha

Ranjan Kumar Das Mohapatra,
Dy. Director of Horticulture, Balangir, Odisha

Odisha, a state in the eastern part of India is basically an agricultural state. The state holds second position in vegetable production and self-sufficient in many vegetables like brinjal, tomato, chilly, okra, cucurbits, greens etc. But, the economic condition of a vast majority of tribal people is not good. As per 2001 Census, the Scheduled Tribe (ST) population of the State of Odisha is 8,145,081. This constitutes 22.1 percent of the total population of the State and 9.7 per cent of the total tribal population of the country.

Of all the states of India, Orissa has the largest number of tribes, as many as 62. in terms of percentage they constitute an impressive 24 percent of the total population of the state. These tribes mainly inhabit the Eastern Ghats hill range, which runs in the north-south direction. More than half of their population is concerned in three districts of Koraput (undivided), Sundergarh and Mayurbhanj.

Per household land ownership among tribal households is extremely low at 1.12 standard acres per household. The situation of marginal ST households which constitute more than 50% of tribal landowners is even more precarious, with their average landholding working out to only 0.44 standard acres. Now with this meager area, they can grow cucurbits round the year to boost their economy.

The tribal farmers grow many cucurbits like small gourd, pointed gourd, spine gourd, ridge gourd, bitter gourd, bottle gourd, pumpkins, watermelons etc. but often fail to market them in proper time resulting in poor revenue. This is primarily because most of the crops are grown at a time in the on- season and after harvest there arises flooding of these vegetables at a time in the market leading to distress sale. Therefore the challenge of growing these crops under protected condition in the off season has arisen like never before.

A walking tunnel with polythene roof of only 1000 meters square is proving to be highly profitable. It has been seen that from that polyhouse, on an average, Rs.1, 00,000.00 (Rupees One Lakh) only can be earned from cucumber only. Growing of water melons in poly houses has been extremely profitable in Israel. There is no doubt why this will not be the same case in India also. The tribal farmers should come forward to take advantage of this by establishing poly houses for which the Government is providing subsidy.

Further, good agronomic practices need to be followed by the tribal farmers for better yield. Technology like single line trellis system is gaining popularity and hence should be widely adopted by the tribal farmers as well. The state Government of Odisha is assisting the farmers in this aspect also. Very often, lack of adequate pollination seriously affects the yield of cucurbit crops. Hence, use of bumble bees for pollination inside the poly houses should be promoted.

There exists a good market for vegetables grown organically. Cucurbits are by and large more hardy than brinjal and tomato and relatively less attacked by disease and pests. Hence efforts should be taken to grow organic cucurbits and to certify them also by proper authority.

An ideal thing for the tribals to adopt cucurbits can be summarized in the following model, assuming the average land holding to be one acre.

Name of the crop	Area to be taken up	Time of planting	Expected Yield	Rate of the produce	Net Profit
Pointed Gourd	0.4 acre	November to December	30 quintals	Rs. 2000 per Qtl.	40,000
Small Gourd	0.2 acre	June to July	10 quintals	Rs. 1000 per quintal	5000
Bitter Gourd	0.2 acre	January	10 Quintals	Rs. 2000 per Qtl.	10000
Other Gourds and cucumber	0.2 acre	March	10 Quintals	Rs.1500 per quintal	10000

The above figures relate to growing in open field condition. A tribal family can earn at least Rs. 65000.00 (Rupees Sixty Five Thousand) only from one acre of land in a year. The profit can be at least 4 times if the crops are taken in protected structures. Another gourd which has very good market demand is the local spine gourd which sells not less than Rs.50 per kg. in Odisha. This crop grows very well in hilly tracts. Area expansion of this commercial crop can also prove to be a good bread earner for the tribals of Odisha.

To conclude, cucurbits can change the future of tribal farmers of the state if they come forward to grow the crops under protected condition with good agronomic practices.



Dillip K. Dora*, B. K. Mohanty and T.Moharana
Orissa University of Agriculture and Technology, Bhubaneswar

The family of cucurbitaceae, consisting of approximately 125 genera and 960 species, gives avenue to a large number of vegetable crops most of which are confined to the tropical and subtropical regions of the World. Dioecious cucurbits, most of which are indigenous, form an important segment of the cucurbitaceae family. Pointed gourd (*Trichosanthes dioca* Rox.b), Spine gourd (*Momordica dioca*....) and Ivy gourd (*Coccinia grandis* L.) are considered to be the three most important dioecious cucurbits. Pointed gourd and spine gourd are mostly cultivated in the eastern part of India, particularly in Odisha, West Bengal, Assam, Bihar and Eastern Uttar Pradesh. However, Ivy gourd, on the other hand is grown both in eastern and southern states of India. These crops remained neglected for quite a long time. However, in the recent past these crops have received attention and some work in the field of crop improvement and crop agronomy has been worked out. This article mostly highlights the results of the work done so far in India and some recommendations have also been made to elevate the status of these crops.

Dioecious cucurbits - Rich source of Nutriceuticals

- ❖ Good source of carbohydrate, protein, vitamin A, C and also minerals such as Ca, Mg, K, P etc.
- ❖ Improves digestion.
- ❖ Good for skin health and improves complexion.
- ❖ Lowers cholesterol and blood sugar level.
- ❖ Balances cough and bile.
- ❖ Useful in itching and burning sensation.
- ❖ Used as medicine in jaundice, viral infections, flu, anemia, gastritis.
- ❖ Leaves of pointed gourd are used for curing edema and root causes mild purgation.
- ❖ Rich in antioxidants which protect the body against oxidative stress by neutralizing free radicals.

CROP AGRONOMY

Propagation:

All the crops under reference are commonly propagated by vegetative means. Seeds are generally not used for commercial propagation owing to poor germination and unpredictable sex expression.

Pointed gourd is conventionally propagated through vine cuttings, root suckers and layered plants. However, Availability of quality planting material is a major limitation in pointed gourd cultivation round the year, so optimization of in-vitro plantlets development can be a tool for large scale propagation and conservation of germplasm. However, efforts are on to develop standard protocol for large scale multiplication of planting materials. Initial attempt in this direction has yielded good results. Plant regeneration in pointed gourd has been achieved from shoot tips, nodal explants and immature/mature cotyledons.

In spine gourd use of stem cutting with two nodes is recommended for commercial multiplication. IVY gourd is also propagated by using stem cutting.

Nutrient management:

No much work has been done on nutrient management of dioecious cucurbits. However, for pointed gourd with the routine application of well decomposed farm yard manure/poultry manure/blended city compost, nitrogen, phosphorous and potash at the rate of 90 kg, 26 kg, 33 kg/ha respectively are recommended. Nitrogen and potash need to be applied in five split doses for better results. For IVY gourd and spine gourd, though no standard recommendation is available, it is observed that all the three crops respond very well to integrated nutrient management practice involving organic manures and in organic fertilizers.

Water management:

These crops need watering at frequent intervals (2-5 days) at the crop establishment phase and thereafter the crop(s) need irrigation at an interval of 3-4 days depending upon the water holding capacity of the concerned soil. Flowering fruit set and development stages are identified as critical as far as irrigation is concerned. Of course at present drip irrigation is recommended to meet the water requirement to the tune of expectation of these crop(s).

Training:

Field observations indicate that by providing support to these crops through aerial support systems such as bowers, arches, trellis could increase fruit yield upto 14% in case of pointed gourd when compared with production on the ground.

Weed management:

At the initial stages of growth of the crops under reference weed management is very much essential which could be better accomplished by the need based application of registered herbicides and manual weeding.

Pollination:

Drying of flowers 1-2 days after anthesis, or yellowing and drying of fruit 5-7 days after anthesis is a common problem during summer. This has been attributed to the lack of pollination and subsequent ovule fertilization during summer months.

Both problems underscore the importance of maintaining a ratio of 1 staminate to 10 pistillate plants.

Harvest and Post Harvest Care:

These fruits are harvested at immature stage while still tender with immature seeds. There is immense scope to initiate work on post harvest care and value addition of these crops. Both pointed gourd and spine gourd have got high export potential. Hence, post harvest work relating to packaging, transport and development of value added products needs immediate attention.

Crop Improvement

The dioecious cucurbits are commonly propagated by vegetative means. Hence, most of the crop improvement work has been confined to clonal selection. The method of clonal selection is based on nature of the tuberous roots and vines. The varieties of pointed gourd developed through clonal selection of roots and vines. The available improved varieties developed so far are enlisted below (Table 1). The presently cultivated spine gourd and IVY gourd genotypes are based on selection of superior lines. It is further suggested that the mutation breeding is possible to obtain variation. Gamma irradiation and chemical mutagens such as EMS/MMS could be explored to induce variation. It is also possible to find out new bud sports developed through mutation which could be exploited.

Hybridization program are expected to create improved recombinants and transgressive sergeants. The Hybridization process is slow because of poor seed germination and unpredictable sex ratio. Further, evaluation of male parents is not possible. However, pollen could be evaluated through female parents by developing bi-parental progenies. Initial work on inter specific hybridization between *Momordica cochinchinensis* and *Momordica dioca* taken at OUAT has resulted in the development of six hybrids out of which DF1 proved to be best. Nevertheless, inter specific hybridization of spine gourd has been worked out at CHESS, Bhubaneswar by taking advantage of polyploid breeding.

Thrust Areas

- ❖ Exploring the possibility of growing pointed gourd as an intercrop inside newly planted fruit orchards and plantations.
- ❖ Quality planting materials of male and female plants need to be multiplied separately and distributed among farmers, maintaining proper proportion as recommended.
- ❖ Encouraging farmers to grow the dioecious cucurbits with aerial support system such as bowers, arches, trellis so as to ensure effective pollination, higher production of quality fruits.
- ❖ Efforts need to be initiated for invitro multiplication of planting materials.

- ❖ Agro-techniques for these crops, grown under different farming systems need to be standardized and recommended.
- ❖ Integrated management of nutrient, insect pests and diseases need to be developed and recommended.
- ❖ Attempts need to be taken to grow these crops under low cost protected structures such as naturally ventilated poly house and shade net houses with mulching and micro irrigation facilities so as to prolong the cropping duration, which in turn would help the farmers to get higher yield and quality produce.

Extension

There is enough scope to generate awareness among the growers to prioritizing the dioecious cucurbits such as pointed gourd, spine gourd and Ivy gourd in their cropping schedule. This could be better accomplished through print and electronic media and the Krishi Vigyan Kendras functioning under O.U.A.T. in different districts of the state.



**LEAD LECTURES
&
ABSTRACTS**

SESSION I

**GENETIC RESOURCES IN CUCURBITS: DIVERSITY,
CONSERVATION AND UTILIZATION**

Specifics of Genetic Diversity, Trait-specific Germplasm and Conservation Status of Indigenous Cucurbits

Joseph John K

Principal Scientist & Officer in Charge, National Bureau of Plant Genetic Resources, Regional Station, KAU P.O, Thrissur-680656, Kerala

Abstract

As part of region-specific and crop-specific germplasm explorations, a total of 605 accessions in various Cucurbits comprising Bitter gourd (200 accns.), oriental pickling melon (23 accns.) Cucumber (23 accns.), Snake gourd (43 accns.), pumpkin (97 accns.) and other cucurbits and wild related species were assembled from Southern humid zone comprising Kerala, Karnataka, Tamil Nadu, Goa, Lakshadweep Islands, Andaman & Nicobar Islands and from North Eastern Hill region comprising parts of Assam, Mizoram, Tripura and Arunachal Pradesh. All important wild related species of *Cucumis*, *Trichosanthes*, *Momordica* and *Luffa* were collected and conserved including rare and threatened taxa like *Cucumis silentvalleyi*, *C. indicus*, *C. setosus*, *C. hystrix*, *C. muriculatus*, *C. javanicus*, and *C. leosperma*. Wide hybridization between various cultivated melon groups and Cucumber with their wild and weedy forms were carried out and resulting progenies conserved for utilization. Aphid and fruit rot tolerant lines and marker traits like yellow/creamy tender fruit colour or ornamenteally parched skin in slicing Cucumber, drought resistance and fruit fly resistance in *C. melo* subsp. *agrestis*, prolific bearing non bitter forms of *C. melo* subsp. *melo* (wild), scented and non-bitter wild melons besides representative collections in cultivar groups like *acidulous*, *flexosus*, *momordica*, *cantlopensis* and *malensis* were also assembled. IC 550203 *C. melo* subsp. *callosus* showed resistance to drought, downy mildew, *Alternaria* fruit rot, yellow mosaic virus, aphid and fertile F1 and F2 with various melon groups were made and conserved. *C. muriculatus* which is a new record for India is distinct from *C. hystrix* and has non bitter crisp tender fruits used in the same way as slicing cucumber in Mizoram. It is worth domestication as a crop for North East. *C. hystrix* is reported to be a good source of powdery mildew resistance used in China for improvement of slicing Cucumber. Non bitter and cross compatible edible forms of *C. melo* subsp. *agrestis* collected from Lakshadweep beach sand may offer scope for salt tolerance and drought tolerance in Melon cultivar groups.

Mizoram collections of Cucumber having high carotenoid and orange-yellow flesh are unique and offer scope for breeding carotenoid rich Cucumber for 'raitha' preparations and curries. JB/11-60, JB/11-91 and JB/11-126 have a carotene content above 2 μ g and JB/11-217, JB/11-60 and JB/11-91 have total carotenoid content above 4 μ g/100g. Cucumber collections JB/11-229, IC 539818 and JJK/10-601 showed field resistance to leaf blight and bacterial fruit rot. Small white salad cucumber (IC 439588) is very much popular among farmers in Hassan district (Karnataka) for its culinary traits. African horned Cucumber (*C. metuliferus*) has excellent shelf life extending beyond 6 months at room temperature and can be used as a fruit as well as a substitute for slicing Cucumber.

Ash gourd variability (27 accessions) comprising small medicinal (*Neykumbalam* of Kerala used in *Kushmandarasayanam*) to scented forms from North East were amassed. The Mizoram-Tripura- Arunachal collections of Ash gourd are unique in plant morphology with extended shelf life and acclaimed scented flesh. It falls under a second edible species, distinct from *B. hispida*. Promising collections for various traits like extra-long fruits (58-60cm- JB/11-93, JB/11-238), high fruit weight (JB/11-238, JB/11-213) and prolificacy (10-19 fruits/ plant) (JB 11-185 A, JB/11-53, JB/11-54 and JB/11-181) were identified. Oyster nut (*Hodgsonia macrocarpa*) growing wild and as a semi-domesticate in Tripura and adjoining states are a potential edible oil source worth domestication. The genus *Momordica* with about 7 species in India are unique in that all are fruit and leafy vegetable with medicinal properties. High level of nematode resistance was observed in *Momordica dioica* and *M. sahyadrica* forms of Western Ghats which can be easily combined in to Teasel gourd. Extra-long fruit stalk in teasel gourd is advantageous for pollination and fruit fly management. Wide variability for fruit stalk length, fruit size, shape and colour was observed in Teasel gourd assembled from North Eastern states. IC 553771 from Havelock Island of Andaman was found prolific with single fruit size up to 100g and single plant yield of 5kg/ season. Its male plants are prolific flowering as good pollen source. Teasel gourd germplasm showed good variability for fruit shape and yield and yield contributing fruits. Single fruit weight above 80g and cylindrical/ doom shaped fruits were observed in JB/11-83, JB/11-178B, JB/11-173, JB/11-176, JB/11-86, JB/11-122, JB/11-93 and JB/11-169. JB/11-214, JB/11-57, JB/11-79 and JB/11-179 have round heavy fruits weighing around 80g. Sweet gourd (*M. cochinchinensis*) was found to be of two distinct morphological types, the mainland Indian types and Andaman types. The Andaman collection IC 567240 was found to be prolific (over 60 fruits/vine) and less bitter compared to IC 553689 (Arka Neelachal Araktha).

In bitter gourd IC 596981 and IC 596983 (both from Mizoram) were found good genotypes with fruit weight in the range of 200-250g and fruit length of 18-23 cm. High fruit length of 27.5cm was observed in JB/11-124 and JB/11-114, JB/11-15, JB/11-124, JB/11-21 and JB/11-207 were high yielders. Wide variability for morphological characters and yield and yield contributing traits were observed in wild and semi-domesticated bitter gourd. Field resistance to powdery mildew was observed in IC 582471, 582420 and IC 582449. Semi domesticate landraces of small bitter gourd like *Methipavai*, *Rudrakshahagali* and *Ustha* are high-value vegetables. Drought tolerance manifested through continuous flowering and fruiting in acute water scarce condition was observed in IC 598107, IC 598170, IC 598171, IC 598169, IC 598172, IC 598168, IC 582420, IC 582434, IC 582471 and IC 582449.

Good variability in ridge gourd and smooth gourd were also collected from Jhoom lands of Mizoram and Tripura and are under regeneration. Extra-long ridge gourd (JB/11-32 with 65 cm long fruits) and scented Ridge gourd are specific to tribal pockets of North East India.

Ex situ conservation strategies for cucurbits

P. E. Rajasekharan

*Division of Plant Genetic Resources, Indian Institute of Horticultural Research
Hessaraghatta lake PO, Bangalore 560 089*

Abstract

The cucurbitaceae consist of approximately 125 genera and 960 species, mainly in tropical and subtropical regions. All species are sensitive to frost. Most of the species in this family are annual vines but there are also woody lianas, thorny shrubs, and. Plants monoecious (commonly), or dioecious (commonly), or polygamomonoecious, or hermaphrodite (rarely). Pollination entomophilous and includes some of the most ancient cultivated plants known which gives challenges for conservation Seeds are best suited for storage in gene banks but for species that do not set seeds or produce sterile or recalcitrant, it is difficult to conserve. Seeds need to survive when subjected to drying. Hence only seeds of those species, which can withstand drying upto to 10% moisture level could be stored in Gene Banks. Tissue culture techniques are of great interest for collection, multiplication and storage of plant germplasm. The method allows propagating plant material with high multiplication rates in an aseptic environment. Virus-free plants can be obtained through meristem culture in combination with thermotherapy, thus ensuring the production of disease-free stocks and simplifying quarantine procedures for the international exchange of plant germplasm. The miniaturization of plants allows reduced space requirements and considerable saving in labour costs for the maintenance of germplasm accessions. A major limiting factor affecting the increased use of in vitro conservation has been the concomitant improvement of routine tissue culture techniques and the development of simple cryoprotection methods that enhance recovery processes especially after cryogenic storage. The methods employed vary according to the storage duration required. For medium-term conservation, the aim is to reduce growth, thus increasing intervals between subcultures. For long-term conservation, cryopreservation, i.e. conservation at ultra-low temperature, usually in liquid nitrogen (-196°C), the aim is to establish base collections conserved to posterity. Application of cryogenic techniques for conserving NGD in pollen would enable extended use of male gametophytes in research related genetic enhancement in cucurbit species. It also could facilitate

use of pollen carrying valuable dominant traits for introgression into pre-breeding lines, and expression in the F_1 generation. In situ (on-farm) conservation of landraces of cucurbits refers to plants that are conserved or in the very place where they developed their present day characteristics and a major objective of in situ strategies is to maintain evolutionary processes. In situ conservation is also a powerful strategy to integrate farming community, and local institutions into the national PGR system so that monitoring of genetic resources could be done at local scale. In order to maintain and use landraces for sustainable manner, landrace must be useful, competitive with other options a farmer might have and contribute to the food security and possible increase in a farmer's income. Biotechnology has made possible DNA conservation of plant species, in the form of extracted DNA or as genomic DNA libraries. However, this technique needs advanced technological inputs to match with the importance and requirement for the species in question; to justify its need as a practical conservation strategy. In principle, storing DNA is simple, easy, cheap, and is widely applicable A review of the current status of ex situ conservation of cucurbit species will be discussed along with protocols developed.

Diversity in Bottle gourd [*Lagenaria siceraria* (Mol) Stand] germplasm in Maharashtra

N. Dikshit¹, M. A. Nizar¹, N. Sivaraj² and Dinesh Chand¹

¹National Bureau of Plant Genetic Resources, Regional Station, Dr. PDKV Campus, Akola-444104

²National Bureau of Plant Genetic Resources, Regional Station, Hyderabad-5000030

Abstract

Bottle gourd (*Lagenaria siceraria*) is one of the most popular Cucurbitaceous vegetable crops grown in tropical and sub-tropical parts of the world. India is considered as the secondary centre of diversity. It is known as *Bhopla*, *Bhopda*, *Dudhibhopla*, *Dudha*, *Kaddubhopla*, *Lockiand Kaddhuin* local language (Marathi). Twenty six accessions of bottle gourd germplasm comprising cultivated (14) and wild (12) were collected from 21 agro-ecological niches covering 14 districts in Maharashtra region viz. Ahmednagar, Akola, Amaravati, Aurangabad, Buldhana, Hingoli, Jalna, Nanded, Nandurbar, Nashik, Prabhani, Pune, Washim and Wardha. The collection site included cultivated fields, natural wild habitats, farm store, farmers' backyard, kitchen gardens and other sources. The fruits and seeds of both cultivated and wild were subjected to study for qualitative and quantitative analysis. The collected germplasm exhibited very interesting variation in the qualitative characters of fruits such as shape, luster, blossom end, ridges etc. Six types of fruit shape were recorded among the wild bottlegourd germplasm viz., Dumbell, elongate, elliptic, globular, goose neck and pyriform while four types (curved, elongate, globular and pyriform) recorded among cultivated edible types (Figs. 1&2). Wide range of variability were also recorded in the quantitative traits for several fruit and seed characters, viz., fruit length (10.8-69.4cm.), perimeter of the fruits (23.5-64.5 cm), green fruits weight (102.05-1852.69 g.) seed length (1.47-1.64 cm), seed width (0.47-0.66 cm) and 100 seed weight (9.92-21.94 g.) in cultivated germplasm while in the wild germplasm the fruit length ranges from (14.2-31.8 cm), perimeter of the fruit (29.7 – 57.6 cm), green fruit weight (538.23-1593.26 g), seed length (1.34 – 1.66 cm), seed width (0.46 -0.62 cm.) and 100 seed weight (14.6 g.) (Table 2). The qualitative and quantitative traits expressed fairly a good spectrum of fruits diversity in Maharashtra for its cultivated and wild relatives. In order to discover distribution of cultivated and wild forms in the current climate change regime, Maximum entropy (Maxent) modelling was performed and the models presented in Figs. 3 & 4 for wild and cultivated forms respectively. The generated models were compared with Eco crop model, a component of DIVA-GIS (Fig. 5) for the suitability for cultivation of useful bottlegourd germplasm and identifying potential regions for its on-farm conservation. The present investigation helped in preparing a comprehensive map on the existence of diversity/ variability and also provided a fairly good idea on cultivated and wild relatives' diversity in the state of Maharashtra.

Multivariate analysis of genetic divergence of *Solena amplexicaulis* (Lam) Gandhi

T. Maharana, B. R. Sethy and Kaberi Maharana

Orissa University of Agriculture & Technology, Bhubaneswar - 751003

Abstract

Family *Cucurbitaceae* consists of 117 genera and 825 species. Out of them nearly 20 species belong to 9 genera and cultivated for vegetable. Among them *Solena amplexicaulis* is a less known vegetable but of excellent quality. The tender fruits are eaten as vegetable, ripe fruits are scarlet colour, sweet and attractive to birds. As per result of the present study, 15 genotypes were grouped into two clusters and the large cluster in seven sub-clusters. The characters contributed more towards cluster formation were girth of edible fruit, number of fruits per plant and the inter-nodal length. The grouping of by Tocher's method shows close correspondence with the dimensional depression of the genotype by the first two canonical variants.

Genetic variability studies in snake gourd (*Trichosanthes cucumerina*L.)

Padmaraja, S. R. Prakash, M. Kumara, B.R .Santhosh, and G N. Thyagaraj

Division of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru -560 065, Karnataka

Abstract

The present study was undertaken to elicit information on the nature of variability of snake gourd genotypes during 2011 at Department of Horticulture, UAS, GKVK, Bangalore. The phenotypic co-efficient of variation was more than the genotypic co-efficient of variation for almost all the character under study. Both growth and yield attributing characters like number of primary branches per plant, productive length of vine, number of nodes per vine, inter nodal length, node at which first female flower appearance, number of fruits per plant, mean fruit weight, fruit length, fruit girth, flesh thickness, size of the cavity, number of seeds per fruit, fruit fly infestation, downy mildew incidence and yield per plant showed high genetic advance over per cent mean with high heritability. The genotypes GKVK SG-16, GKVK SG-7, GKVK SG-13, GKVK SG-8 and GKVK SG-14 were found to be early flowering and higher yield per plant. The genotypes GKVK SG-9, GKVK SG-8, GKVK SG-14, GKVK SG-5, GKVK SG-13, GKVK SG-7 and GKVK SG-16 were found to be moderately resistant to fruit fly and downy mildew disease.

Collection, Characterization and Conservation of Indigenous Genotypes of Ash Gourd (*Benincasa hispida*) under Narayanpur District of Chhattisgarh

Manoj Kumar Sahu¹, DeoShankar² ·Rajshree Gayen³ M.S.Urre⁴

¹SMS, Horticulture, Krishi Vigyan Kendra (IGKV) Narayanpur, Chhattisgarh

²Scientist (Horticulture) SG College of Agriculture and Research Station, (IGKV), Kumhrawand, Jagdalpur - 494 005

³Scientist (Horticulture), Directorate of Extension Services, IGKV, Raipur - 492 006

⁴SMS Entomology, Krishi Vigyan Kendra Narayanpur

Abstract

The ash gourd, (*Benincasa hispida*) Cong is also known as wax gourd, or petha. It is classified under cucurbits of minor importance though it is cultivated almost throughout India. The immature fruit is consumed as vegetable. The fruit is largely used for making confectionery and "bari". The present investigation was undertaken during kharif 2013-14 at KrishiVigyan Kendra Farm (IGKV) Binjali, Narayanpur (C.G.) India. The experiment was aimed to collect, characterize and evaluate 30 indigenous genotypes of Ash gourd, in augmented block design in single replication. The mean and range were estimated during characterization of 30 genotypes. The morphological characterization was done as per National guidelines to conduct the tests for Distinctness, Uniformity and Stability (DUS) of Ash Gourd genotypes under the heads plant growth habit, fruit characters, flesh characters and seed characters. Thirty indigenous genotypes of Ash gourd (*Benincasa hispida*) viz. NPAG-12-1, NPAG-12-2, NPAG-12-3, NPAG-132-4, NPAG-12-5, NPAG-12-6, NPAG-12-7, NPAG-12-8, NPAG-12-9, NPAG-12-10, NPAG-12-11, NPAG-12-12, NPAG-13-13, NPAG-13-14, NPAG-13-15, NPAG-13-16, NPAG-13-17, NPAG-13-18, NPAG-13-19, NPAG-13-20, NPAG-13-21, NPAG-13-22, NPAG-13-23, NPAG-13-24, NPAG-13-25, NPAG-13-26, NPAG-13-27, NPAG-13-28, NPAG-13-29, NPAG-13-30, collected from Narayanpur and Orchha blocks of Narayanpur district of Chhattisgarh. Genotypes were categorized in to different groups as per character recorded and character contributions. Range, mean was estimated as per observation recorded from different genotypes of Ash gourd. For plant growth habit, genotypes were categorized into three groups short, medium and long and highest frequency was observed (46.66 %) in long. For fruit skin colour genotypes were categorized into two groups white and green and highest frequency (56.66 %) was observed in white. For fruit shape genotypes were categorized into three group oblong, round and round oval and highest frequency (43.33 %) was recorded in round oval. For fruit texture genotypes were categorized into three groups soft spongy, smooth and fibrous and highest frequency (40.00 %) was observed in fibrous. For seediness genotypes were categorized into three groups low medium and high and highest frequency (36.66 %) was recorded in high. The number of fruit per plant was ranges from 6-15 nos. and fruit weight ranges from 5.15 - 13.20 kg. Characterization of genotypes provided the information on morphological agronomic and biochemical aspects of the material that is essential for gene bank management and conservation of the Ash gourd (*Benincasa hispida*).

Collection, Characterization and Conservation of Indigenous Genotypes of Pumpkin (*Cucurbita moschata*) under Narayanpur District of Chhattisgarh

Manoj Kumar Sahu¹, Rajshree Gayen², M. S. Urre³and Deo Shankar⁴

¹SMS, Horticulture, Krishi Vigyan Kendra (IGKV), Narayanpur, Chhattisgarh

²Scientist (Horticulture), Directorate of Extension Services, IGKV, Raipur - 492 006

³SMS Entomology, Krishi Vigyan Kendra, Narayanpur

⁴Scientist (Horticulture) SG College of Agriculture and Research Station,

(IGKV), Kumhrawand, Jagdalpur - 494 005

Abstract

The Pumpkin [(*Cucurbita moschata*) Duch.exPoir] is the most commonly grown *Cucurbits* species in India. It is an important vegetable grown almost all over India. It is one of the few vegetables possessing a long shelf life.. The fruit is mostly consumed as vegetable. The present investigation was undertaken during kharif 2013-14 at KrishiVigyan Kendra Farm (IGKV) Binjali, Narayanpur (C.G.) India. The experiment was aimed for collection, characterization and evaluation of 10 indigenous genotypes of Pumpkin, in augmented block design in single replication. The mean and range were estimated during characterization of 10 genotypes. The morphological characterization was done as per National guidelines to conduct the tests for Distinctness, Uniformity and Stability (DUS) of Pumpkin genotypes under the heads plant growth habit, number of fruit per plant, mature fruit skin colour, fruit ridge (rib) shape, fruit weight, flesh characters, fruit length and fruit width. Ten indigenous genotypes of Pumpkin viz. NPP-13-1, NPP-13-2, NPP-13-3, NPP-13-4, NPP-13-5, NPP-13-6, NPP-13-7, NPP-13-8, NPP-13-9, NPP-13-10 collected from Narayanpur and Orchha blocks of Narayanpur district of Chhattisgarh. Genotypes were categorized in to different groups as per character recorded and character contributions. Range, mean was estimated as per observation recorded from different genotypes of pumpkin. For plant growth habit, genotypes were categorized into three groups plants having short vine, medium vine and long vine and highest frequency was observed (40 %) in medium vine. For fruit skin colour genotypes were categorized into two groups yellow and light green and highest frequency (60%) was observed in yellow. For fruit ridge (rib) shape genotypes were categorized into two groups round and narrowly winged and for mature flesh colour genotypes were categorized into two groups yellow and orange and both the group shown equal frequency (50 %). The number of fruit per plant was ranges from 6-12 nos. and fruit weight ranges from 10.16 - 31.25 kg. Fruit length, fruit width and flesh thickness ranges from 20.20 cm-45.80 cm, 18.20cm-25.10cm and 3.20 cm-6.30cm, respectively. Characterization of genotypes provided the information on morphological agronomic and biochemical aspects of the material that is essential for gene bank management and conservation of the Pumpkin (*Cucurbita moschata*).

Assessment of genetic diversity in Ivy gourd [*Coccinia grandis* (L.) Voigt.] genotypes of North Eastern Region using RAPD markers

J. Saikia, S. Acharjee, D.B. Phookan, P. Talukdar and L. Saikia

Department of Horticulture, Assam Agricultural University, Jorhat-785013, Assam

Abstract

Ivy gourd [*Coccinia grandis* (L.) Voigt.] is an underexploited cucurbitaceous semi-perennial creeper and mostly termed as poor man's vegetable. Ivy gourd has antioxidant and antihistamine properties and is great for the immune system. It has insulin like effect on blood sugar levels. In the present investigation, twenty two genotypes of Ivy gourd have been studied to assess the molecular diversity using RAPD markers. A total of 26 RAPD markers produced 118 amplicons, of which 52 amplicons were polymorphic (44.06% polymorphism), indicating a high degree of diversity. RAPD based dendrogram showed dissimilarity values from 0.10 to 1.09 also suggest that the genotypes represent a genetically diverse population. The genotype IG-14 was clearly separated from the rest of the genotypes based on the RAPD primers. On the basis of clustering, it was indicated that genotypes collected from some district of Assam had a narrower genetic diversity among themselves as compared to genotypes collected from different agro-ecological conditions of North Eastern Region.

Growth and yield of cucumber as influenced by different sowing dates under polyhouse as off season crop

Ms. Sapna Boruah and Dr. Deepa Borbora Phookan

Department of Horticulture, Assam Agricultural University, Jorhat-785013

Abstract

Cucumber experiments under polyhouse were conducted during 2012-13 and 2013-14 in the Experimental Farm of the Horticulture department of Assam Agricultural University under Naturally Ventilated polyhouse. The study was carried out in Randomized Block Design with five replications. Seeds of cucumber cultivar Alisha F-1 was sown in four sowing dates at monthly intervals from middle of October to middle of January. Umbrella system of pruning was adopted. Seeds are sown at a distance of 60 cm between rows and 30 cm between plants. Different growth and yield attributing parameters were determined. Among the four different dated of planting the highest number of 19.43 fruits per plant was recorded in January sown crops which was significantly highest than the other dates of sowing. The highest yield of 4.28 kg per plant was recorded from two years pooled data in January sowing crop. Though there was no significant difference in the female to male ratio. However two years pooled data showed that the highest fruit setting percentage of 43.38 was recorded in January sowing crops. As an off season crop cucumber can be grown in all the four sowing dated however, January sowing date gives the best performance.

Variability in ivy gourd germplasm from sub-humid Aravalli hill regions of Rajasthan

Sheetal Tak, R. A. Kaushik, and K. D. Ameta

Rajasthan College of Agriculture, MPUAT, Udaipur - 313001

Abstract

Ivy gourd (*Coccinia grandis*) also known as Kundru is an under-exploited cucurbit vegetable originated in India. It is a dioecious perennial grown in southern and eastern states of India. The crop is raised by planting three nodded cutting taken from female plants, yielding fruits in summer and rainy season. In South and Central India, fruiting is round the year, while in North India, fruiting terminates when the temperature comes down in November. Fruits are good for diabetic patients. Considering the above said facts, an attempt has been made to collect the available variability in this crop from Southern Rajasthan for further improvement. Sixteen diverse germplasm were collected during August-Sept. 2013 from different villages of Aravalli hills region of Udaipur (Raj.) and evaluated for different characters like fruit diameter, fruit length, weight, volume, specific gravity, moisture percentage in fruit, T.S.S., number of seed per fruit, and pedicle length. The result revealed a significant difference for all the characters under study. The economically important parameters like fruit diameter ranged from 17.8 (CG-7) to 32 mm (CG-1), fruit length ranged from 36.7 (CG-8) to 54.9 mm (CG-14), highest fruit weight and volume was observed in CG-1 (35.4 gm) and (42.8 ml/100ml) respectively. Specific gravity was highest in CG-8 (1.46 gm/cc). Moisture content in Ivy gourd fruits was found in the range of 82.1 to 90.8 %. T.S.S. varied from 2.7 to 4.6⁰ Brix, number of seeds per fruit was highest in CG-14 (106). CG-2 germplasm recorded the highest pedicle length 6.02 cm followed by germplasm CG-6 (4.4 cm). This germplasm will be propagated at experimental site of MPUAT, Udaipur for further evaluation and utilization.

Diversity of Cucurbitaceous crops in North East India

S. D. Warade, R. K. Dubey, V. Singh, V. B. S. Chavan and A. K. Pandey

College of Horticulture and Forestry, Pasighat 791 102

Abstract

The North Eastern region of India comprising eight states namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim has vast geographical variations. The region is also represented in six agro climatic zones. The North Eastern region is one of the richest reservoirs of genetic variability and diversity of different cucurbitaceous crops. The diversity for cucurbitaceous crops

of this region has mainly been managed by the tribal people. Considerable diversity exists among the region in cucurbitaceous crops including variation in plant type, morphological and physiological characteristics, reactions to diseases and pests, adaptability and distribution. Enormous diversity occurs in semi domesticated and wild types in local pockets. Such types have been selected locally by tribal as part of their routine vegetable requirement. The most important crops genera included *Cucumis*, *Cucurbita*, *Momordica*, *Trichosanthes*, *Luffa* and *Benincasa*. Many of these have not only contributed towards diversity but also are rich gene pool for important traits. These materials along with their close wild relative serve as genetic stocks by plant breeders for development of improved vegetable varieties. Nowadays, molecular approaches available for many plant species offering tremendous possibilities for genetic diversity assessment, improving our understanding of complex characters as well as providing the basis for effective breeding strategies when coupled with more traditional methods.

D² square analysis study in Bottle gourd [*Lagenaria siceraria*(Molina) Stand]

B. Muralidharan, V. Kanthaswamy and B. Sivakumar

Pandit Jawaharlal Nehru College of Agriculture and Research Institute (TNAU), Karaikal, U.T. of Puducherry

Abstract

Bottle gourd [(*Lagenaria siceraria* (Mol.) Standl.] is an important member of family *Cucurbitaceae* grown commercially in almost all parts of India during summer as well as rainy season. The natural genetic variation for many of the economically important traits is considerable in this crop. In any plant breeding programme needs clear understandings of the existing genetic divergence in the available population. Crosses involving genetically divergent parents were expected to show a broad spectrum of genetic variability would increase the range of frequency distribution and provide better chance for improving the economic characters under consideration and greater scope for isolating the transgressive segregates in the advanced generation. Investigation on the evaluation of bottle gourd genotypes for yield was carried out in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Coastal region of Karaikal, U.T. of Puducherry from January to March 2011. The twenty four diverse genotypes were evaluated for *per se* performance, phenotypic and genotypic variability, heritability, genetic advance and genetic divergence. The association and contribution of different characters towards yield were also estimated for all the twenty four genotypes for 19 characters. All the accessions were evaluated for nineteen characters viz., vine

length, number of primary branches, node at which first male flower appears, node at which first female flower appears, days to first male flower anthesis, days to first female flower anthesis, sex ratio, days to first harvest, fruit length, fruit width, fruit cavity, flesh thickness, fruit weight, number of fruits per vine, number of pickings, number of seeds per fruit, weight of 100 seeds, yield per vine and total soluble solids. Twenty four genotypes formed nine clusters which revealed the fact that geographical diversity need not necessarily be associated to the genetic divergence. Among the nine cluster formed, the cluster IX recorded highest mean values for eight characters namely vine length, node number at first male flower appearance, days to first male flower anthesis, days to first female flower anthesis, sex ratio, days to first harvest, fruit cavity and number of seeds per fruit followed by cluster VII which recorded highest mean values for fruit width, number of fruit per vine, number of picking and weight of 100 seeds. For all among the nine clusters it was observed that cluster VIII was the largest with seven genotypes followed by cluster VII which had four genotypes. Parental lines from these two distant cluster may be used in hybridization programmes which is likely to produce wide variability and transgressive segregations with high heterotic effect. Two genotypes were formed in the cluster's I, II, III, IV, V, VI. Cluster IX had only one genotype. The intermating of individuals from these two clusters can express high heterotic vigour and throw desirable segregants on hybridization. The present investigation reveals that the genotype NDBG-164 was considered as the best genotype among the 24 genotypes studied based on the *per se* performance and genetic divergent analysis. In the present study, an attempt was made to obtain such information in bottle gourd. The nature and magnitude of genetic diversity among twenty four bottle gourd genotype assembled from different geographical locations was measured through multivariate analysis using Mahalanobis D² to identify suitable and best genotype for hybridization. There is possibility of getting suitable recombinant for yield and quality during future breeding programme.

Genetic variability studies in bottle gourd [*Lagenaria siceraria*(Mol.) Standl] Coastal region of Karaikal

B. Muralidharan, B. Sivakumar and V. Kanthaswamy

Pandit Jawaharlal Nehru College of Agriculture and Research Institute (TNAU),
Karaikal, U.T. of Puducherry

Abstract

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] belongs to the family Cucurbitaceae having chromosome number 2n = 22. Bottle gourd is one of the most important cucurbits cultivated in India. It is grown in summer season as well in rainy season Yadav *et al.* (11). Under the genus *Lagenaria*, six species are reported in world. Improvement in any character depends on genotypic variability, better are the

chances for selection of superior genotypes. Evaluation of the genotypes for important agronomic traits is an important aspect for any improvement programme. Therefore, the assessment of genetic variability in crop is of paramount importance in selecting the best genotype for making rapid improvement in yield and related characters as well as to select most potential parent for making hybridization programme successful. It is, therefore, necessary to know the nature and amount of variation present in the population for bringing about [Ahmed (1)] improvement.

The potentiality of a genotype is measured not only by the mean performance, but also by of the extent of [Allard (2)] variability existing. Genetic variability is the plant breeder's stock in trade without which breeders are powerless to develop a new variety in any crop. It is highly essential to ascertain to what extent the observed variability was determined by genetic causes, for that the estimation of genetic variability is necessary. The extent of genetic variability is more important than the total variation, since greater the genetic variability wider would be the scope for selection.

Bottle gourd is an important fruit vegetable crop having a wide range of variability. The progress of the breeding programme depends upon the extent to which the desirable traits are heritable. High heritability estimate in conjunction with high genetic advance was considered more useful than the heritability estimate alone in predicting the resultant effect in the selection programme. Hence, this study was taken up with 19 morphological traits of bottle gourd to estimate the genetic variability and genetic advance in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute (TNAU), Coastal region of Karaikal, U.T. of Puducherry. Analysis of variance revealed the presence of significant differences among the genotypes for all the characters. Based on the *per se* performance, the genotype NDBG-164 was identified as the best for fruit flesh thickness, fruit weight, yield per vine and estimated fruit yield. High estimates of genetic coefficient of variation for vine length, number of primary branches, node number at first male flower appearance, fruit length, fruit width, fruit cavity, fruit flesh thickness, fruit weight, number of pickings, number of seeds per fruit, weight of 100 seeds and yield per vine indicating that the major part of variability was due to genetic constitution. Heritability in general was high for all the characters except days to first female flower anthesis. High heritability also indicated that there was more number of additive factors for these characters. All the characters exhibited higher values of genetic advance as per cent of mean except node number at first female flower appears, days to first male flower anthesis, days to first female flower anthesis and days to first harvest, it's may be due to predominance of additive gene effects and consequently a distinct possibility of improving these characters by simple selection can be followed. It is inferred that most of the characters exhibited high heritability and high genetic advance which indicated the pre dominance of additive gene action and hence selection is more effective. For the improvement of these traits simple pedigree breeding followed by selection would be rewarding.

Genetic diversity analysis of Ridge gourd based on seed protein profile using SDS-PAGE

***Uzma Khatoon, Rakesh Kr Dubey, Vikas Singh, V. B. S. Chauhan,
S. D. Warade and A. K. Pandey***

College of Horticulture & Forestry, CAU, Pasighat, Arunachal Pradesh

Abstract

In the present study, 40 Ridge gourd genotypes from different part of India were collected and evaluated for genetic diversity using morphological characters and SDS-PAGE analysis. Estimation of protein was done in seeds of forty genotypes of ridge gourd collected for the study. The SDS-PAGE study revealed maximum amount of diversity as compared to morphological data analysis. Considerable variation in number of proteins bands (8-24) was observed using SDS-PAGE. Based on the dendrogram, all the genotypes can be grouped into 2 major clusters which were further sub-divided into two sub cluster each. Among the genotypes CHFRG-11 showed maximum number (24) of protein bands while the minimum numbers (8) of bands were present in CHFSM-12. CHFRG-35 with CHFRG-36 exhibited minimum genetic distance (12.00). It is also observed that genotypes from different regions were to be closely related and genotypes from the same region had different genetic background. Intra-regional diversity could be as a valuable source as inter regional diversity for ridge gourd improvement.

Genetic diversity analysis in Ridge gourd Accessions for future breeding strategy

***Uzma Khatoon, Rakesh Kr Dubey, Vikas Singh, V. B. S. Chauhan,
S. D. Warade and A. K. Pandey***

College of Horticulture & Forestry, CAU, Pasighat, Arunachal Pradesh

Abstract

Forty ridge gourd genotypes collected from different part of India were subjected to D^2 analysis. Multivariate analysis following Mahalanobis D^2 analysis revealed that the studied genotypes of ridge gourd have considerable genetic divergences which were grouped into six clusters, with maximum genetic divergence between cluster IV and cluster V. The cluster IV with genotype CHFRG-8, CHFRG-12, CHFRG-6, CHFRG-10 and CHFRG-22 were the more divergent for improving vine length, number of node per vine, crop duration, pedicel length, fruit length, fruit diameter, number of fruit per plant and fruit yield. Cluster VI with 9 genotypes are found to be promising

lines for improving number of node to first pistillate flower appearance, days to first pistil late flower anthesis, days to first staminate flower anthesis and days to first fruit harvest. The genotype CHFRG-13 in cluster V was identified as genetically divergent for average fruit weight and hence, genotypes in these clusters can be utilized in crop improvement programme as donor parents for improving all these characters. Days to first staminate flower anthesis contributed maximum towards divergence followed by number of fruit per plant, days to first fruit harvest, fruit length, fruit diameter and pedicel length. Hence, the above characters are to be taken into consideration while attempting crop improvement studies in ridge gourd.

SESSION II

**PROGRESS IN CROP IMPROVEMENT, INNOVATIVE
BREEDING TECHNIQUES AND FUTURE STRATEGIES**

Recent advances in molecular breeding for abiotic stress tolerance in cucurbits

Ramavtar Sharma¹, KV Bhat², RK Bhatt³

¹Principal Scientist, Div III (PIP&PM), CAZRI, Jodhpur; ²Principal Scientist & Head, NRCDNAFP, NBPGR, New Delhi; ³Head, Div III (PIP&PM), CAZRI, Jodhpur

Abstract

Plants are found to grow on varying habitats ranging from very cold to hot tropical regions, saline to acidic soils and dry hot deserts to water submerged conditions. In order to survive in diverse conditions plants evolved various mechanisms that broadly fall in two types; constitutive and adaptive. The morphological features that plants have evolved to survive a particular environment are constitutively expressed depicting minor adjustments with changing environment. The survival and productivity of a plant is grossly affected by its capacity to adapt fluctuations in growing environment through regulated gene actions. Plants thwart different climatic and edaphic conditions with an array of biochemical and physiological adaptations, which involve the function of many stress related genes. Hence any attempt to improve the stress tolerance requires a better understanding of physiological, biochemical and molecular events.

Plants show various types of morpho-physiological adaptations as a manifestation of varyingly expressed stress induced regulatory genes under different abiotic stresses. The reactions of plants to water stress differ significantly at various organizational levels depending upon intensity and duration of stress as well as plant species and its stage of growth. The importance of ramified root system in acquiring water has long been recognized. A prolific root system can confer the advantage during water stress but correlations are not high to establish the fact unequivocally.

At cellular level abiotic stresses including water deficit conditions, often results in imbalance between energy intake and consumption by photosynthetic organ leading to the production of reactive oxygen species (ROS) and inability of the plant to control them, which eventually cause denaturation of functional and structural proteins. As a consequence, diverse environmental stresses often activate similar cell signaling pathways and cellular responses, such as the production of stress proteins, up-regulation of anti-oxidants and accumulation of compatible solutes.

Cucumber and melon are important crops cultivated world over in varying habitats ranging from the Northern regions of the temperate climate zone to the tropics. Spatial isolation and the need to adapt to diverse environmental conditions have induced various adaptation mechanisms.

A study under NAIP project “Bioprospecting of genes and allele mining for abiotic stress tolerance” has led to identification of species/genotypes tolerant to water stress. The study has also indicated importance of some morphophysiological traits associated with tolerance level. The role of various antioxidants has also been investigated, and novel genes were identified through transcriptome analysis.

In the last few years useful genomic tools have been build that can be applied to breeding programs in order to obtain better melon and cucumber varieties. Existing genomic resources include the ICuGI database (cucumber genomics database) (<http://www.icugi.org>) that holds 129067 melon and 513276 cucumber ESTs, several genetic maps developed using different genetic backgrounds, oligo-based microarray, a physical map and a collection of BAC end sequences and whole genome sequences using different techniques and genotypes.

Present status and future breeding strategies for bitter gourd cultivation

T.K. Behera

Division of Vegetable Science, IARI, New Delhi 110012

Abstract

Bitter gourd (*Momordica charantia* L.) breeding was initiated in India probably with the first report of hybrid vigour as high as 191.3% for yield by B. P. Pal and H.B. Singh at IARI in 1946. They observed heterobeltiosis for number of male and female flower, vine length, fruit size and total yield per plant. The diverse morphological characters (i.e., sex expression, growth habit, maturity, and fruit shape, size, colour and surface texture of bitter gourd in India provide for relatively broad phenotypic species variation. The genetic diversity analysis based on morphological and molecular markers has been well documented in this crop. The present paper reviews the genetic and molecular basis of bitter gourd breeding. Although bitter gourd has a long cultivation history, the molecular research and breeding efforts have been started later than the other major cucurbitaceous vegetables. Our breeding strategy is mainly focused on yield, quality, maturity period, fruit characteristics, economic traits, etc. Research is also being carried out for disease resistance particularly to find out the source of resistance and application of DNA markers in molecular breeding. In recent years, various bitter gourd varieties have been bred with characteristics of high-yield, early maturity, strong female line, etc. mostly through selection by variety purification, hybridization, heterosis and mutation breeding. Some remarkable bitter gourd varieties/hybrids were Pusa Do Mausami, Pusa Vishesh, Kalyanpur Baramasi, Pant Karela 2, Hirkani, Priya, Preeti, Pusa Hyrid 2, Prachi, Abhishek, VNR-28 etc. The breeding strategies particularly strengthening the research on development and identification of molecular makers for economic traits, marker assisted selection for

yield improvement need to be adopted frequently. This paper also deals with the use of micro-propagation for maintenance of gynoecious lines and extraction of predominately gynoecious genotype with high frequency of female flower was systematically studied by using gynoecious lines. Use of modern molecular tools and techniques such as transcriptome analysis, molecular mapping and their application in trait specific breeding is also discussed. The variety/hybrid suitable for protected cultivation, resistant/tolerant to abiotic stresses resistance (high temperature, water deficiency, salt tolerance), non-bitter cultivars with high medicinal benefits [e.g., proteins (charantin), polypeptides (polypeptide-K), glycoalkoloids, phenolics and other antioxidants], pest resistance (e.g. virus, powdery and downy mildew and fruit fly, red pumpkin beetle) and better fruit quality [e.g., later seed maturity, minimized ridges, uniform green colour in a range of fruit size (small, medium, and large)] are the major breeding strategies for bitter gourd cultivation.

Present status and future breeding strategies for improved cultivation of Bottle gourd

B.Varalakshmi¹, Pitchaimuthu, M¹ and D.C. Lakshman Reddy²

¹Division of Vegetable Crops, ²Division of Plant Biotechnology

Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore-560 089

Abstract

Bottle gourd [*Lagenaria siceraaria* (Mol.) Standl; 2n=22] is one of the important cucurbitaceous vegetable crops grown throughout the tropical and sub-tropical regions of the world. It is considered to be one of the earliest species of plants to be domesticated by humans, originated from Africa and cultivated in Africa, Asia and America. Bottle gourd is a cultivated annual monoecious species, with five wild perennial dioecious species, namely *L. breviflora*, *L. rufa*, *L. sphaerica*, *L. abyssinica* and *L. guineensis* which are confined to Africa and Madagascar. In India, it occupies an area of 1,13,920 ha with a production of 20,89,890 t and a productivity of 18.34 t/ha (NHB Database, 2013). It is cultivated in Uttar Pradesh, Punjab, Gujarat, Assam, Meghalaya, Rajasthan, Karnataka, Tamil Nadu, Andhra Pradesh and Kerala for immature fruits which are used for culinary purposes. Bottle gourd is a rich source of vitamins, carbohydrates, proteins, fats and minerals. The seed kernels contain 45% oil and about 35% protein. In West Africa, mature seeds are used in sauces; dry shells of differently shaped fruits are still being used as utensils or decorative ornaments and musical instruments. Of late, in India bottle gourd is attaining fast popularity among the health conscious urban elite because of its antioxidant, an antidiabetic and anti-obese properties. However, caution must be exercised not to consume 'bitter' bottle gourd juice which poses serious health problems. The increased awareness about

bottle gourd health benefits has encouraged round the year cultivation of this potentially important vegetable in almost all parts of the country, except in very cool regions during winter. Different types i.e. long, round and oblong types are generally grown but for the export generally cylindrical fruits are preferred.

Bottle gourd breeding has started initially at IARI, New Delhi and IIHR, Bangalore way back in 1970's with an objective to improve the yield potential of this crop. In this direction, the first improved varieties, Pusa Summer Prolific Long and Pusa Summer Prolific Round from IARI were released for commercial cultivation in 1975, followed by Arka Bahar from IIHR, Bangalore during 1984. Later on research on bottle gourd has started at many other ICAR Institutes and SAU's viz., IIVR, Varanasi, NDUA&T, Faizabad, PAU, Ludhiana, GBPAUT, Pantnagar, CSAUA&T, Kanpur etc., for the improvement of yield in different genetic backgrounds. This has resulted in the release of several high yielding varieties like, Narendra Jyothi, Narendra Dharidara, Kashi Ganga, Pusa Naveen, Pusa Sandesh, Punjab Komal, Pant Lauki etc. Bottle gourd being highly cross pollinated vegetable crop, maintenance breeding of open pollinated varieties poses a biggest challenge to the breeders. Subsequently the focus of bottle gourd breeding in the country has shifted towards the development of hybrids which ensures uniformity of the produce, in addition to the several well-known advantages like, increased yield potential with the expression of very high hybrid vigour (106-115%), ease of the production of F_1 hybrids and the ability to produce large quantity of seeds per pollination. This has paved the way for the release of several high yielding hybrids viz., Pusa Megdhut, Pusa Manjari, Pusa Hybrid-2, Kashi Bahar, Narendra Shankar Lauki etc., by the public sector organizations and many popular hybrids like, Warad, NS-421, Mridula, Raveena, Arya, Anmol, Gadda etc., by the Private sector companies in India.

In spite of the availability of many varieties and hybrids in the country, still the productivity of bottle gourd hovers around 18t/ha only. Main reasons for this low productivity can be attributed to major production constraints like outdated production practices followed, non-availability of varieties resistant to abiotic and biotic stresses. Majority of lines are highly susceptible to low temperature (below 8°C) and usually die if the temperature drops below 5°C. Fruit setting is affected adversely in very hot summer (around or above 40°C) due to either very poor or no activity of insect pollinators. Among the germplasm, variability for these traits is observed and breeding off-season cultivars may be feasible. Downy mildew (*Pseudoperonospora cubensis*) is a serious disease and crop damage can go up to 80-90% during rainy season and powdery mildew (*Sphaerotheca fuliginea*) is serious during early summers and damage ranges from 50-60%. At times, anthracnose, *cercospora* leaf spot, fusarium wilt and *cucumber mosaic virus* also cause serious crop losses to the growers through reduction in growth and yield. Of late, gummy stem blight (*Didymella bryoniae*) is becoming a very serious problem of bottle gourd cultivation. Fruit fly is the major insect problem (about 50% damage) and white flies pose a serious risk as vector transmitting viral diseases caused by *poty* virus in bottle gourd.

Though rich diversity of bottle gourd is available in India, so far most of the research was only aimed at the improvement of yield through conventional breeding methods. Development of bottle gourd varieties/hybrids with pest and disease resistance will not only enhance the productivity of bottle gourd but also ensures safe production by reducing the pesticide application thereby avoiding human health hazards. Very little attention was given for resistant breeding in bottle gourd, apart from few scattered studies conducted to locate the source of resistance to some of these diseases and pests. They identified the bottle gourd genotypes, Gutkha, Sarika, Kaveri, IIHR-8-1 and VRBG-12 as resistant to downy mildew; GH-3, GH-9 and winter Ghiya -1 as resistant to anthracnose; IIHR-8-1, IIHR-19-1 and IIHR-23 as resistant against powdery mildew; Pusa Naveen, Pusa Santushti, Pusa Samridhi and Pusa Sandesh were moderately resistant against *Cercospora* leaf spot and Elina was resistant to fruit fly. Further systematic research on these identified sources is yet to be conducted to develop disease and pest resistant cultivars. Identified bottle gourd germplasm with peculiar leafy calyx in male flowers and segmented leaf type can be utilized as morphological markers in the conventional breeding programs.

Identification of molecular markers linked to disease and pest resistance will significantly hasten the conventional breeding programs through marker assisted selection. Even though, bottle gourd is important cucurbit with a relatively small genome size of 334Mb, at present, very few molecular genetic/genomic resources are available in public domains like NCBI. Molecular breeding work has been initiated very recently in India with basic research on identification if molecular markers for assessing genetic diversity existing in the gene pool. Internationally also very little research work has been done on bottle gourd, that too in the interest of bottle gourd being used as an efficient rootstock for watermelon cultivation. In USA, Japan and Israel in order to provide healthy and efficient rootstocks, sources of resistance against various biotic stresses like fusarium (FR-Ganggeon and FR-Sinsegae), powdery mildew (PI 271353) and virus (PI 271357 and PI 271359, USVL-1-8 and USVL-5-5) were identified in bottle gourd. Transgenic 'sCAX2B bottle gourd' rootstock developed in Korea has improved watermelon quality through the translocation of nutrients and/or water toward enhancing the biomass of scion. Partial sequencing of bottle gourd genome by Pei Xu *et al.*, (2011) from China resulted in the development of 402 SSR markers which may hasten marker assisted breeding programs for efficient incorporation of desired traits. In order to protect the plant breeders and farmers rights, Protection of Plant Varieties & Farmers Rights Authority (PPV&FRA), New Delhi has recently notified Bottle gourd crop for registration. Keeping all these aspects in view, the concerted efforts put in for the crop improvement and production technology would probably not only increase bottle gourd productivity in the country but also ensures its due place among vegetables which it deserves.

Future thrusts:

1. Emphasis should be laid to develop varieties/hybrids resistant to major diseases like downy mildew, powdery mildew & gummy stem blight and pests like fruit fly integrating marker assisted selection.
2. Development of bottle gourd varieties/hybrids with low and high temperature tolerance should be given priority to expand the area of cultivation and to ensure year round availability.
3. Root stock breeding for the development of efficient bottle gourd rootstocks with disease and pest resistance needs to be initiated.
4. Development of varieties with different shapes and colors with decorative/ornamental purposes can be attempted to tap their export potential.
5. Scope of development of varieties rich in seed oil and protein can be explored which may become an easy-to grow source of protein and oil in the hot humid tropics

Present status, and future breeding strategies for improved cultivation of ridge gourd and sponge gourd

A.D. Munshi, A.K. Sureja and T.K. Behera

Division of Vegetable Science, IARI, New Delhi-110 012

Abstract

The genus *Luffa* ($2n = 2x = 26$) is economically important to tropical agriculture, where some of its members possess relatively high nutritive value and important medicinal attributes. Well known members of this genus include *Luffa cylindrica* (L.) M.J. Roemer and *Luffa acutangula* (L.) Roxbury which are extremely popular as a vegetable in the tropical and subtropical regions of the World and are widely cultivated in India, Southeast Asia, China, Japan, and areas of Africa.

The goals for sponge and ridge gourd cultivar development include increased plant productivity (i.e., increased fruits per plant) which can be achieved by breeding for increased lateral branching, higher femaleness (i.e., female:male sex ratio), greater frequency of the first pistillate flower originating at a lower nodes, and earlier fruit maturity. Increased fruit quality can be obtained through breeding for uniform, thin, cylindrical medium-long (25-35 cm) non-fibrous fruits that are bitter-free, possess tender skins but have a relatively long shelf life. Selection is practiced against blossom-end (e.g., enlarged blossom-ends) and stem-end (e.g., thick stem-ends) anomalies.

Both yield and fruit quality can be enhanced by incorporating genes for insect and disease resistance (e.g., fruit fly, red pumpkin beetle, powdery mildew, downy mildew, and virus) during cultivar development. Acceptable fruit color is consumer dependent, where whitish green, light green or dark green fruits are preferred in sponge gourd and green or dark green fruits are sought after in ridge gourd. Breeding objectives are also based on commercial use. For instance, sponges derived from sponge gourd must be elongate in shape, uniform, light colored, debris- and seed-free. Sponges must also be firm, possess a strong network of fibres of moderate mesh, and have a length of at least 35 cm.

With a view to develop nutritious ridge gourd variety, a field as well as a laboratory study was conducted (Karmakar *et al.*, 2013) to quantify and enumerate the genetic control for antioxidant properties and mineral content in fruits. The hybrids were found to be superior over their parents for various nutritional traits such as ascorbic acid, total carotenoids and total phenolics content; in vitro antioxidant activity in the form of DPPH-RSA, ABTS-RSA and CUPRAC; and P, K, Ca, Na, S, Fe, Zn and Mn content in the fruits. All the nutritional parameters exhibited higher values of dominance variance over the additive genetic variance, more than unity value of average degree of dominance and low narrow-sense heritability ($\leq 50\%$). The antioxidants and mineral content in the fresh fruits are predominantly attributed by the non-additive genetic component. Hence, the various tools of hybrid breeding would be useful to breed antioxidants- and minerals-rich genotypes of ridge gourd .Karmakar *et al* (2012) further observed highly significant mean squares due to parents, hybrids and parents versus hybrids; and GCA and SCA for yield and antioxidants (ascorbic acid, totalcarotenoids, total phenolics, DPPH-RSA, ABTS-RSA and CUPRAC assay) indicate the existence of abundant genetic variation. The per se performance and combining ability of hermaphrodite parents (Satputia Long and Satputia Small) and hybrids of “monoecious 9 hermaphrodite” cross were found to be superior for antioxidants along with yield potential. The cross combinations with superior per se performance coupled with high SCA estimates and having at least one hermaphrodite parent would be useful for concentratingdesirable alleles to improve the antioxidants and yield simultaneously. Thus, hermaphrodite lines in combination with monoecious counterpart have enormous potential to breed “genotypes for higher antioxidants”without compromising yield in ridge gourd.

Pradeepkumar *et al.* (2012) identified cytoplasmic male sterility (CMS) in ridge gourd, where two dominant male fertility restorer nuclear genes (*Rf1* and *Rf2*; either in homozygous dominant or heterozygous dominant condition) with complementary gene action are responsible for the restoration of male fertility. These genes were detected in cross-progeny originating from crosses made between a male sterile (MS) and male fertile ridge gourd lines.

Inheritances of hermaphorditsm in ridge gourd was studied by Karmakar *et al.* (2012) and found that the trait was governed by two recessive genes. On the basis of the information obtained, Munshi *et al.* (2013) developed a genetic stock of

gynoecious ridge gourd which segregates into 50% gynoecious plants and 50% hermaphrodite plants (satputia type) and the gynoecy was maintained by sibbing with hermaphrodite line.

Sponge gourd in India is severely affected by Tomato Leaf Curl New Delhi Virus (ToLCNDV), where it can cause 100% crop loss during the rainy season. Islam *et al.* (2010) studied the inheritance of resistance to ToLCNDV and found that resistance to this virus is controlled by a single dominant gene resident in lines DSG-6 and DSG-7. Subsequently, Islam *et al.* (2011) used bulk segregant analysis (BSA) to identify two sequence-related amplified polymorphism (SRAP) markers were closely linked to the ToLCNDV-susceptible gene, while two SRAP markers were closely-linked to the resistance gene. Given their linkage relationships to resistance genes, these markers are candidates for marker-assisted selection (MAS), which could provide for more efficient early seedling disease selection that would reduce the time of ToLCNDV-resistant cultivars.

Munshi *et al.* (2012) recently developed a sponge gourd germplasm, 'DSG-6', that is highly resistant to *Tomato Leaf Curl New Delhi Virus* (ToLCNDV). Subsequently, Saha *et al.* (2013) amplified the nucleotide-binding site (NBS) domain of the putative resistance gene candidates (RGCs) from DSG-6. Sixteen non-redundant RGCS sequences with un-interrupted open reading frames (ORFs) and high amino acid sequence homologies (60–98%) to various nucleotide-binding site leucine-rich repeat (NBS-LRR) proteins were identified using the GenBank database. Of these, six and ten sponge gourd (sg) RGCS are associated with the Toll Interleukin Receptor (TIR) and non-TIR group of NBS-LRR genes, respectively. The sgRGCS consist of conserved NB-ARC [homologous region shared with APAF-1 (apoptotic protease-activating factor-1), R proteins and CED-4 (*Caenorhabditis elegans* death-4 protein)] domain from the P-loop nucleoside triphosphatase (NTPase) family with characteristic P-loop, Kinase-2, RNBS-A, Kinase-3A, and GPL motifs. The comparative analysis of expression profiles of sgRGCS in asymptomatic and field-driven symptomatic leaf tissues of ToLCNDV resistant and susceptible genotypes indicate that the expression of the RGCLc28 motif in resistant genotypes are consistent. The differentially expressed RGCLc28 motif of DSG-6 has a strong association with the resistance trait against the leaf curl and mosaic disease in sponge gourd and may serve as important genomic resource for candidate gene discovery in future in *Luffa*.

Most of the genetic improvement in sponge gourd and ridge gourd has been the result of rigorous phenotypic selection which has resulted in the release of many popular open-pollinated cultivars in Asia, particularly India. Over the last two decades, heterosis breeding has been exploited and numerous high performance F₁ hybrids have been developed in *Luffa* species, particularly in China. In the future, sponge gourd and ridge gourd breeding will emphasize the development of nutritious, high-yielding cultivars with superior resistance to major diseases and exceptional fruit quality for both domestic and foreign markets.

Present status and future breeding strategies for improved cultivation of Cucumber and native melons in India

Pitchaimuthu M¹, Varalakshmi B¹, Kanupriya² and Ansar Wani¹

¹Division of Vegetable Crops, ²Division of Plant Biotechnology

Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore-560 089

Abstract

The genus *Cucumis* consists of 52 species, out of these 20 are cultivated extensively for human consumption all over the world. Among these, both Cucumber (*Cucumis sativus*) and native melons viz., Snap melon (*Cucumis melo* var. *momordica*), Long melon (*C. melo* var. *utilissimus*), Oriental pickling melon (*C. melo* var. *canomon*), acidulous and makuwa (Dosakai) and Kachri (*C. callosus*) are important cucurbitaceous vegetables originated from India (Chakravarthy 1982). These are used as salad, pickle, cooked vegetables when unripe and reservoir of genes governing important traits such as yield, nutritional quality and various biotic and abiotic stress resistance. In India, cucumber and gherkin are grown in an area of 26,500 ha with a production of 1.68 million tones and a productivity of 7.5 t/ha. Melons are cultivated in an area of 44,500 ha with a production of 1 million tones (FAO STAT 2012). India, being primary center of origin for cucumber and native melons, so far research focus was on genetic diversity, collection, evaluation and conservation. Species distribution studies were done by several workers to exploit this diversity for heterosis. During 1970, first gynoecious F₁ hybrid, Pusa Sanyog was developed at IARI with high yield (76 % heterosis), but it was only suitable for cooler conditions, did not perform well under Northern and southern plains (Gill et al 1973). Later on several tropical gynoecious hybrids viz., DCH-1 and DCH-2 suitable for high temperature tolerance and long day conditions (More 1993); Phule Prachi and Phlue Champa tropical gynoecious promising F₁ hybrids (More et al., 2002), PCUCH-1 and four parthenocarpic hybrids for high yield and better quality (Dinesh Kumar & Singh et al., 2005); AACUH-1 AACUH-2 were released by various public sector Institutes. Open pollinated varieties namely DC-2 (Pusa Uday), Poinsett, Himangi, Poona Khira, Balam Khira, Swarna Poorna and Swarna Agethi were developed and commercialized. However none of these varieties or hybrids are resistant to downy mildew and CGMMV. Research on resistance against mildews through conventional and molecular breeding approaches is currently underway in both ICAR Institutes and SAU's viz., IIHR, IARI, IIVR, GBPVA&T, MPKV and YSPUH&F. Two advance lines IIHR-177-1 and SM 12735 were identified for multiple disease resistance to PM, DM and alternaria at IIHR, Bangalore (Pitchaimuthu et al., 2012), DVRM-1 was identified as CGMMV resistant source and Poinsett was identified as mildew resistant variety only under northern India conditions.

Presently, our focus is on breeding cucumber for refinement of populations derived from intercrossing elite and/or exotic germplasm, the development of inbred lines and commercially acceptable F₁ hybrids resistant to biotic stresses (downy mildew, powdery mildew, CGMMV, CMV & fruit borer) in both slicing and pickling types through phenotypic (PHE) and marker-assisted (MAS) selection. Cucumber has very narrow genetic base, small genome size (~780 Mega base pairs); low chromosome number, and rapid life cycle (three cycles per year) (Staub and Meglic, 1993) and amenable to MAS because it is the first vegetable crop species to be sequenced. Cucumber genome will provide an invaluable genomic resources for biological research and breeding of cucurbits (Huang, Sanwen, *et al.* 2009). In recent years, different molecular markers (RAPD, RFLP, ISSR, AFLP, SSRs, and SNPs) have been employed for the investigation of cultivar origins and taxonomic relationships of several plant species. Use of molecular breeding will increase selection efficacy and reduce breeding cycle size of the population through MAS during back cross breeding and population improvement (Robbins and Staub 2009). Weng *et al.*, (2010) evaluated 821 cucumber genomic SSR primer pairs for map construction, 140 (17.0%) were polymorphic between the mapping parents. Behera *et al.*, (2010) reported PHE and MAS for yield improvement. In order to increase genetic diversity in cucumber, marker-assisted strategy was used through introgression, backcrossing employing *C. hytivus* as a parent (Behera *et al.*, 2011). Pandey *et al.*, (2013) investigated the genetic variation among 44 cucumber accessions using morphological and SSR markers. They observed that the clustering pattern of SSR markers was not in consonance with the groupings based on quantitative traits. The genomic basis of divergence among the cultivated populations was investigated in this study and a natural genetic variant in a α -carotene hydroxylase gene that could be used to breed cucumbers with enhanced nutritional value was discovered. Such investigations of the genome will form the basis for future genomics-enabled breeding (Qi *et al.* 2013).

Most of the native melons in India are cultivated mainly under river bed cultivation and homestead gardens in small pockets. There was no specialized improvement techniques followed except by selection. The improvement of long melon in India was taken up at PAU (Ludhiana), IIVR (Varanasi) and IIHR, (Bangalore). Arka Sheetal has been developed and released through selection at IIHR, Bangalore and Punjab Long Melon-I (H-10) was developed through selection at PAU, Ludhiana. In case of snap melon/phoot is vegetable for an arid and semi-arid regions of Rajasthan. Few promising genotypes viz., AHS6, AHS 10, AHS 50, AHS 54, AHS 64 and AHS 82, have been developed and recommended for cultivation by CIAH, Bikaner. Recently IARI, New Delhi, has identified Pusa Shandar for release. Out of 30 genotypes evaluated during spring-summer season, SM 4, SM 7(O), SM 15-1, SM 18, SM 25, DBSM and AP 6 were found suitable for different yield attributing characters. In case of oriental pickling melon (Kani vellari); three varieties viz., Mudikodu local, Soubhagya and Arunima were released by Kerala Agricultural University. Budamakaya (cooking

cucumber type) has very hard rind and crisp flesh with very good keeping quality. Kachri (*Cucumis callosus*) confined to arid desert region of Rajasthan, is now semi domesticated for its small fruits with little edible portion. CIAH, Bikaner released two types of kachri, AHK-119 and AHK-200 (Seshadri VS and More T.A, 2009).

Major breeding problem in *native melons* is lack of genetic variability present in our Indian genetic stock for various traits, lack of stable sources of resistance to biotic and abiotic stress (Downy mildew, CGMMV, CMV, Gummy stem blight, fusarium wilt and nematodes, fruit borer, fruit fly and leaf minor), lack of moisture stress tolerant varieties and crossing barrier like post fertilization (embryo abortion) which have to be studied in depth in the near future. Dwivedi, *et al.*, (2010) reported sufficient diversity in 121 accessions of 5 different *Cucumis* wild species collected from the part of Aravalli ranges of north-western India. In melons, 375 Mb of the double-haploid line DHL92, representing 83.3% of the estimated melon genome has been sequenced by Garcia-Mas *et al.*, in 2012. Recently Mallik *et al.* (2014) reported diversity in 88 landraces from three melon Groups in two subspecies (*C. melo* subsp. *Agrestis* *Momordica* Group, *C. melo* sub sp. *melo* *Cantalupensis* Group and *Reticulatus* Group) which were collected from the four agro-ecological regions (six sub-regions) of two northern states of the Indo-Gangetic plains of India namely Uttar Pradesh and Uttarakhand. Recently SNP markers for genes belonging to major fruit metabolic pathways were developed

Future strategies should be to use of parthenocarpic genes to increase yield and fruit quality in *Cucumis species*. The use of new technologies (e.g., molecular markers) and genetic stocks [e.g., RIL and nearly-isogenic lines (NIL)] will be increased in the future as they augment very well with conventional breeding. Technologies available in the present day, like next generation sequencing, are helping biologists decipher genome information in a short span of time and apply it to generate genomic information for important horticultural crops. NGS has led to sequencing of whole genomes and transcriptomes provide opportunity for discovery of new, useful information on the genetic control of important traits. Converting these into genetic tools like markers would enhance the efficiency and accelerate the breeding of these crops compared to conventional phenotype-based approaches. Currently, the application of these technologies is much slower in horticultural crops compared to other crops like cereals.

Future Thrusts:

1. Survey, collection, characterization and utilization of vast number of native melons viz., *Cucumis melo*. Var. *momordica*, (Dosaikai) from Andhra Pradesh, *Cucumis melo*. var. *cannomen* from Kerala and Karnataka, Snap melon *C. melo* var. *utilisimus/acidulous*, *agristris* (phoot) from Goa and UP
2. Identification and documentation of superior lines /varieties in various native melons and cucumbers

3. Incorporation of gynoecious and parthenocarpic traits in to tropical cucumber lines
4. Development of downy mildew resistant cucumber hybrids for both open field and polyhouse cultivation with high yield and good qualities.
5. Use of pollinators and bee hives to increase fruit set and yield in native melons and cucumbers.
6. Use of reliable molecular markers to enhance and efficiency of breeding cycle and also distinguish hybrid seeds and selfed seeds

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Present status and future breeding strategies for improved cultivation of pumpkin

Prashant Kumar

Senior Breeder-Vegetables (cucurbit crops), Rasi Seeds (P) Ltd, Bangalore

Abstract

Pumpkin belongs to the *Cucurbita* genus of economically important Cucurbitaceae family. The genus *Cucurbita* consists of 27 species, five of which are cultivated, namely, *C. pepo* L., *C. moschata* Duch. Ex Poir, *C. maxima* Duch., *C. argyrosperma* Huber and *C. ficifolia* Bouche. The pumpkin, *Cucurbita moschata* Duch. Ex Poir is the most commonly grown *Cucurbita* species in India, which is grown commercially as well as a backyard crop. Production is scattered throughout all vegetable growing areas of the country. The major production areas include Uttar Pradesh, Rajasthan, West Bengal, Odisha, Madhya Pradesh, Chhattisgarh, Maharashtra, Tamil Nadu, Kerala and Karnataka. The acreage varies year to year because the crop can be grown almost anywhere with only a small capital investment. It is an underutilized cucurbit crop with an excellent economic potential and nutritional importance. It is less in calories but contains vitamin A and flavonoid poly-phenolic antioxidants such as leutin,

xanthins, and carotenes in abundance. There has recently been increased interest in pumpkin production in India primarily as a fresh market vegetable crop.

Although there have been significant varietal developments of pumpkins over the years in India, but there is still much room for improvement through conventional plant breeding approaches. Previously improvement had been mainly by selection from local types. Some of the improved varieties of pumpkin developed by different institutes and State Agricultural Universities are Arka Chandan, Pusa Viswas, Pusa Vikas, CO-1, CO-2, Sooraj (CM-350), Saras, Ambili (CM-14), Narendra Amrit, Narendra Agrim, Kashi Harit and Solan Badami. Only two F1 hybrids viz. Pusa Hybrid-1 and NDPKH-1 have been developed in country by the public sector. There are several local types of pumpkin grown in different regions of the country. Among the noted cultivars are Indori Local of Madhya Pradesh, Bhadahi of U.P., Baidyabati and Chaitali of West Bengal. In recent years a good number of pumpkin hybrids have been developed and released for commercial cultivation by private seed companies. Some of the major companies working on pumpkin breeding in India are East West, MAHYCO, Century, VNR Seeds, Rasi Seeds and Bejo Sheetal.

Disease susceptibility, non-availability of widely adaptable varieties/hybrids and widespread use of low quality seed are the major limiting factors in harnessing the actual available market potential of pumpkin crop. Pumpkins are threatened by numerous fungal, bacterial and viral diseases. Viral diseases caused by *Zucchini Yellow Mosaic Virus* (ZYMV), *Papaya Ringspot Virus* (PRSV) and *Squash Leaf Curl Virus* (SqLCV) are the major limitations of pumpkin cultivation in India. Viral diseases can cause up to 100% yield losses in pumpkin.

Breeding for increased productivity, earliness, plant characteristics, improved fruit colour and morphology are still major objectives of the current pumpkin breeding programme in India. It should shift towards development of disease resistant variety/hybrids in prioritized market segments coupled with quality attributes, more compact plant growth habit and adaptability to various agro-climatic conditions. Rich genetic diversity of pumpkins in India may serve as the genetic stock to the pumpkin breeders for the development of high yielding and improved varieties and hybrids. It is now the time to utilize the available resources and opportunities to accelerate the breeding programmes by prioritizing the goals for developing hybrids/varieties resistant to disease (mainly viruses) with other desired traits of consumer and grower preference. The future strategies for pursuing pumpkin research should also aim at enriching the germplasm pool and their assessment at target locations for better quality, yield potential and resistance to biotic and abiotic stresses, development of molecular markers for desirable traits, development of value added products, and finally making them available to the farmers.

Present Status and future breeding strategies for improved cultivation of ash gourd, ivy gourd and creeping cucumber (*Melothria*)

Sudhakar Pandey and P. Karmakar

Indian Institute of Vegetable Research, Post Box-01,
P.O.-Jakhani (Shahnshahpur) Varanasi-221305

Abstract

Ash gourd is popularly known as winter melon, wax gourd, white gourd, Chinese preserving melon or white pumpkin. It belongs to a monotypic genus *Benincasa* of cucurbitaceae family with a single cultivated species *hispida*. It is grown in South East Asia, China and India. In India, it is grown in Punjab, Uttar Pradesh, Bihar, West Bengal; northeastern hill (NEH) states; Orissa, Kerala and Tamil Nadu on commercial scale, however, sporadically throughout India. Uttar Pradesh ranks top for area and production among the states cultivating ash gourd. Large numbers of recipes of ash gourd are well known in India. The immature fruit is used as culinary vegetable in West Bengal, Orissa, Kerala, Tamil Nadu and NEH Region of India for preparing variety of dishes. Ash gourd is a nutritionally rich fruit containing vitamins and minerals like calcium, potassium, iron and zinc which are essentially required in human diet. The ash gourd is mentioned in ancient Ayurvedic texts like *Charaka Samhita* and *Ashtanga Hridaya Samhita* for its many nutritional and medicinal properties. Fully ripened or mature fruits are used for preparation of *petha* (candy), sweet or *bari* in Uttar Pradesh. In ash gourd, for *petha* preparation big size (10-15 kg) oval to cylindrical fruits are required, while for household consumption small cylindrical cultivar (1-2 kg) without ash is in demand. The ICAR institute and SAU's have taken the initiative for developing ash gourd varieties suitable for *petha* processing. Seven promising varieties 'Kashi Ujawal', 'Kashi Dhawal', 'Kashi Surbhi', KAG-1, Pusa Ujjwal, PAG-72 and 2 hybrids DAGH-14, DAGH-16 have been released/identified. Generally, yield of ash gourd is 35-40 t/ha but use of improved varieties with efficient agronomic practices and nutrient management, it has shown the yield potential of up to 100 t/ha. The processing method of crystallized *petha* and Kashi *petha* (*petha* with sugar syrup) has also been standardized by IIVR with modification of commercial process. Cultivation of these varieties by farmers has increased their income and also promoting large farmers for establishment of *petha* processing unit to start up as a small scale business. Seedless fruits are easy for processing hence breeding for seedless, or fruits with less seeds and wax less genotype may be the focus of present research for consumption purpose. There is further scope for enhancement of nutritional quality of fruits. Thus, there are large opportunities for scientists to explore this crop in various research aspects. There is need to promote the crop as one of the main

component of vegetable diet. The farmers must be promoted for cultivating new varieties and establishing small scale petha processing units to earn handsome profits in return.

Coccinia grandis (L.) Voigt, is a commonly known as ivy gourd, little gourd, kundru, scarlet gourd, tindori, tindola, and kovai kai. It is native Africa, India, and Asia. The genus *Coccinia* has 30 species confined to tropical Africa, except ivy gourd (*Coccinia grandis*). Ivy gourd occurs wild from Senegal east to Somalia and south to Tanzania, Saudi Arabia, Yemen and India. Ivy gourd was introduced by humans commonly as a food crop to several countries in Asia, Australia, Pacific Islands, the Caribbean, and southern United States. It is a diploid species with $2n=14$. Ivy gourd is an underexploited cucurbitaceous vegetable cultivated almost throughout India. The tender fruit of this crop is used as a cooked vegetable. This plant has used in the indigenous system of medicine in the treatment of diseases such as skin infections, bronchitis and diabetics. The fruit contains appreciable amounts of iron, vitamin A and vitamin C. The tender shoots of the plant are sometimes used as pot-herbs. Ivy gourd is a dioecious, perennial, and herbaceous climber, with glabrous stems, tuberous roots, and axillary tendrils. Fruit is a smooth, green with or without strips, ovoid to ellipsoid berry (2.5–6 cm). Considerable variability of the crop has been observed in Karnataka, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Bihar and northern parts of Kerala. Practically little crop improvement work has been attempted on this crop. Though, locally available landraces are prevalent among the farmers, some improved cultivar i.e.; Indira Kundru-05, Indira Kundru-35, Co-1 and Kashi Bharpoor has been developed through clonal selection. The developed cultivars may be multiplied at large scale and should reach to the farmers. The available variability needs to be collect, conserve and utilized for selection of promising clone. Being an indigenous crop, nutraceutical properties along with active compound should be studied. Ivy gourd is a winter deciduous and during cool and dry season it becomes dormant. Therefore, germplasm should be screened for less dormancy period to facilitate its cultivation round the year. Foliar diseases like anthracnose, powdery and downy mildew reported in this crop but extent of damage not studied and documented. The common insect includes fruit fly, vine borer and spider mites. Being, a vegetatively propagated and cross pollinated crop, there is immense possibility to develop heterotic combinations and individual plant selection. Sex linked markers may be identified for screening of male at seedling stage.

Creeping cucumber (*Solena amplexicaulis* Lam.) is diploid species with $2n=24$ and rarely known underutilized dioecious cucurbit. It is also known as ban-kundri in Bengali, gometti in Marathi and kaduri in Hindi. In tribal region of Odisha tender fruits are used as curry and fried vegetable. Beside, this it can also be used as salad purpose. The tubers, leaves and seeds are extensively used in traditional system for various ailments like hepatosplenomegaly, spermatorrhoea, appetizer, cardiotonic, diuretic and thermogenic. Root is stimulant and purgative. The leaves have good anti-inflammatory activity and also prescribed for skin lesions and other skin diseases.

The whole plant is determined to be a potential source of natural antioxidant activity and also used for the treatment of diabetes. This crop is originated in tropical Asia more specifically in the Indian subcontinent. Beside India, it is distributed in Sri Lanka, Bangladesh, Nepal, China, Indonesia and Vietnam. In India it is found in Kerala, Maharashtra, hilly region of Odisha, Jharkhand, part of West Bengal, Chhattisgarh, Karnataka and North Eastern hilly region. Plants are herbaceous or woody climber or trailer, 2–6 m long, with tuberous roots. Leaves simple, shortly petiolate to sessile, the blade ovate or elliptic, very variable, base cordate or hastate, to 22 cm long; tendrils simple, glabrous. Flowers small; male flowers in condensed racemes, female flowers solitary. This crop is commercially propagated through tuberous root, whereas seeds and stem cuttings can also be used for propagation. Till date no systemic crop improvement work was started. If proper insight on research related to genetic improvement was given, then it can be future cucurbitaceous crop of India. So there is an urgent need of collection, characterization, documentation and conservation of available variability. Among the collected variability, clonal selection may be performed to select best one and quality planting material may be distributed among the farmers for commercial cultivation. The package of practices needs to be standardized and needs popularization to farmers. Tissue culture protocols needs to be standardized for better conservation.

Wide hybridization studies in the genus *Momordica*

L. K. Bharathi

Central Horticultural Experiment Station, Aiginia, Bhubaneswar

Abstract

The genus *Momordica* is a native of paleotropics, comprises of about 60 species distributed in the warm tropics of both hemispheres, chiefly in Africa, out of which 11 species are reported to occur in South East Asia. According to the latest revision of the genus, India is represented by four dioecious species and three monoecious species. The genus includes a major commercial vegetable crop bitter gourd (*Momordica charantia* L.), and a semi domesticated vegetable crop teasel gourd (*M. subangulata* Blume subsp. *renigera* (G. Don) de Wilde). Apart from bitter gourd and teasel gourd all the *Momordica* species occurring in India bear edible fruits esteemed for their medicinal, nutritional properties and taste. Among the monoecious *Momordica* species, the two botanical varieties (var. *charantia* & var. *muricata*) were cross compatible in either direction with high fruit and seed set. However, the F_1

hybrid showed a reduction in fruit shape and size. Hybrid seeds were difficult to obtain between *M. charantia* and *M. balsamina*. But, the F_1 hybrid showed a high bivalent frequency, normal meiotic cycle. From the breeding point of view, the barriers appear to be post zygotic and methods like embryo rescue may be employed to rescue the hybrids for further evaluation. Among the dioecious species viz. *M. dioica*, *M. subangulata* subsp. *renigera*, *M. cochinchinensis* and *M. sahyadrica*, fertile F_1 hybrid could be obtained between *M. dioica* and *M. sahyadrica* without any special treatment. Though F_1 hybrids have been developed without much difficulty in other cross combinations, the hybrid plants were sterile. However, recently, the fertility of the F_1 hybrid in cross combinations viz. *M. subangulata* subsp. *renigera* \times *M. dioica* and *M. dioica* \times *M. cochinchinensis*. There have been few attempts at inter-specific crosses between monoecious group and dioecious group but none succeeded so far. The reason for their incompatibility were attributed to poor pollen germination and inhibition of growth of pollen tubes in the upper part of the style before reaching the embryo sac. A fully fertile interspecific (*M. suboica*), an autoallo polyplloid was produced by crossing natural tetraploid *Momordica subangulata* subsp. *renigera* ($2n=4x=56$) with induced tetraploid *M. dioica* ($2n=4x=56$) which can be propagated easily through root cutting, set fruits naturally (>90% fruit set), has extended harvesting period and gives higher yield. The reason for the natural fruit set is due to insect visits (moths & honey bees) due to strong musky scent which is inherited from *M. dioica*. *M. suboica* combines the desirable attributes and this hybrid is expected to revolutionize cultivation of teasel gourd and spine gourd by saving labour and better propagation efficiency.

Development and evaluation of parthenocarpic gynoecious cucumber varieties for protected cultivation and preliminary studies on inheritance of parthenocarpic traits

A. D.Munshi, T.K. Behera, and A.K. Sureja

Division of Vegetable Science, IARI, New Delhi-110012

Abstract

Parthenocarpic gynoecious cucumber varieties are suitable for polyhouse cultivation as these varieties develop fruits automatically without any pollination. Now a days many of the private seed companies are selling varieties / F_1 hybrid's of parthenocarpic cucumber at a very high price as their seeds are being sold on per seed basis. Keeping in view these facts, programme on development of parthenocarpic gynoecious varieties for protected cultivation was undertaken during 2010 at Division of Vegetable Science, IARI, New Delhi. The initial material was an exotic collection which was broken by using Silver thiosulphate (3Mm) for induction of male flowers and individual plant selection was carried out and generations were advanced during spring summer and *kharif* season respectively, under insect proof net house. In winter season of 2013-14, seventeen breeding lines which were advanced to F_8 and showing true gynoecious and parthenocarpic behaviour were evaluated under low cost polyhouse. The line DPaC-6 was observed as most promising as it expressed 25.0% and 16.7% higher yield than check Pant Parthenocarpic Cucumber- 2 and Asma, respectively. Though its yield (122.5 t/ha) was less than the best check F_1 hybrid Kion (127.0 t/ha), it was statistically at par. The yield obtained by DPaC-6 (122.5 t/ha) can be considered as quite high since, it was obtained during off-season (winter season) under low cost polyhouse without using any energy. The inheritance studies of fruit skin colour and parthenocarpy was also conducted by crossing DPaC-6 and monoecious cucumber variety Pusa Uday. The F_1 progeny showed intermediate colour between dark green DPaC-6 and light green Pusa Uday. The F_1 progeny showed true gynoecious parthenocarpic behaviour as its fruits were seedless and developed without pollination which suggested that gynoecious parthenocarpic trait is governed by single dominant gene. The F_1 progenies were advanced to F_2 and also simultaneously backcrossed with parthenocarpic line DPaC-6 to confirm the monogenic dominant nature of parthenocarpy.

Heterosis and combining ability studies in ridge gourd [*luffa acutangula* (L.) roxb.]

Anand Narasannavar, Prakash, M. Kumara and
B. R. Siddappa Madarkhandi
College of Horticulture, Arabhavi

Abstract

The investigation on heterosis and combining ability in ridge gourd was carried out during year 2011-2012 at the department of Vegetable Science, Kittur Rani Chanamma College of Horticulture, Arabhavi. Fifty-one hybrids derived by crossing 17 lines with three testers were evaluated along with parents in RBD and data was subjected to line x tester analysis. The analysis of variance revealed that 24 of the 26 characters were significant for treatments (genotypes). The magnitude of heterosis over the commercial check (Naga) was very high in desirable direction for number of seeds per fruit (238.80 %), number of leaves at 90 days after sowing (DAS) (172.12 %), number of branches at 90 DAS (141.38 %), flesh thickness (70.27 %), number of leaves at 45 DAS (66.97 %), node to first male flower (-56.92 %), fruit diameter (55.09 %), number of fruits per vine (53.85%), average fruit weight (40.86 %), sex ratio (-40.34%), fruit length (36.91%) and per cent fruit set (36.45%). The hybrid KRG-3 x ASM followed by KRG-3 x PN (13.80%), KRG-10 x PN (12.45%) and KRG-11 x PN (6.00%) exhibited maximum heterosis (23.61%) for total yield per vine over the Commercial check (Naga). The cross KRG-9 x ASJ, KRG-10 x PN, KRG-12 x ASJ, KRG-5 x ASM and KRG-11 x PN were identified as good specific combiners for total yield per vine and lines KRG-3, KRG-11, KRG-10, KRG-2, KRG-1 and KRG-8 were identified as good general combiners for total yield per vine in order of merit. Comprehensive assessment of parents by considering gca effects of all 24 characters studied has resulted into identification of lines viz, KRG-2, KRG-3 and KRG-4, KRG-11 and KRG-16 and the testers, ASM as good combiners and PN as average combiner. Studies on combining ability variance revealed that non additive gene action was predominant for total yield per vine, fruit yield per plot, fruit yield per hectare, number of fruits per vine, average fruit weight, fruit length, vine length at 45 DAS, number of leaves at 45 and 90 DAS, number of branches at 90 DAS, days to last harvest and these characters could be further improved for combining ability through recurrent selection schemes or heterosis breeding.

Evaluation of spine gourd (*Momordica dioica Roxb.*) genotypes under Konkan agro-climatic conditions of Maharashtra

M. Y. Godbole, J. C. Rajput, Y. R. Parulekar, P. C. Haldavanekar and V. G. Magar
Department of Horticulture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli

Abstract

The experiment was conducted Central Experiment Station, Wakawali, Konkan Krishi Vidyapeeth, Dapoli (Maharashtra), during Kharif season under Vegetable Improvement Scheme. Fifteen genotypes of Kartoli (*Momordica dioica Roxb.*) were evaluated in a RBD with three replications. The phenotypic variances were higher than the corresponding genotypic variances. Similarly, the genotypic variances were found to be higher than their respective environmental variances. The phenotypic, genotypic and environmental variances were higher for vine length, fruits per vine and yield per vine. The ratio of genotypic variance to phenotypic variance was higher for length of vine, fruit length, fruit breadth, and average fruit weight, fruits per vine and yield per vine. The characters viz., primary branches, secondary branches, days to first flowering and days to first harvest recorded lower values of the ratio indicating influence of environment in their expression. The values of phenotypic coefficient of variance and genotypic coefficient of variance were higher but closer for fruits per vine (64.6% and 63.6%), yield per vine (63.5% and 62.36%) and yield per hectare (63.5% and 62.35%) indicating less influence of environment. Moderate values of PCV and GCV for the characters viz., primary branches per plant, secondary branches per plant, and days to first harvest, fruit length and average fruit weight confirmed moderate variability for these characters in the population. Higher values of heritability in broad sense were observed for characters viz., vine length (91.8%), fruit length (98.7%), fruit breadth (99.3%), average fruit weight (99.99%), fruits per vine (96.9%) and yield per vine (96.45%) suggesting important role of genetic constitution in their expression. Absolute values for genetic advance ranged from 0.341 to 519.282 suggesting scope to improve the characters under study to the maximum possible through selections. The genetic advance as per cent of mean coupled with heritability in broad sense was high for vine length, secondary branches, fruit length, average fruit weight, fruits per vine and yield per vine. Days to first flowering, days to first harvest and fruit breadth recorded moderate heritability along with moderate GAM indicating control of non-additive genes for these characters. The culture DPL-MD-7 could be rated as the best for its high yielding performance, with associated growth characters, other qualitative aspects and acceptability from consumer's point of view. The culture DPL-MD-4 and DPL-MD-2-1 could also be regarded as promising types. The culture DPL-MD-6, having highest fruit weight, could be employed to increase fruit weight of spine gourd while considering improvement for yield.

Combining ability for yield and its Components in Pumpkin (*Cucurbita moschata* (Duch. Ex. Poir).

*Gururaj S. Kakamari, R. C. Jagadeesha, T. Shanatappa,
H. R. Basavarajappa, Vijayakumar Rathod and H. Rekha
K. R. C. College of Horticulture,
University Horticultural Sciences Arabhavi 591 218*

Abstract

A field experiment was carried out at Kittur Rani Channama College of Horticulture, Arabhavi, Karnataka. To study the combining ability through diallel cross in pumpkin involving six parental lines. The study revealed contribution of both additive and non-additive gene action controlling the expression of yield and its components. Epistasis was pronounced for all the characters. Among parents, KP-31 and KP-51 ranked as top general combiners for yield and its components. Higher yield was associated with increased number of fruits, average fruit weight and fruit diameter. Good specific combination involved high x low general combiners. Exploitation of heterosis appeared to be limited. Three crosses KP-31x KP-26, KP-17xArabhavi local and KP-51xArabhavi local were identified for developing high yielding genotypes of pumpkin with other desirable characters.

Genetic variability, correlation and path analysis in *Valan Kakri* (*Cucumis sativus* var. *utilissimus*L.)

*R.K. Jat, K.D. Ameta, R. A. Kaushik, R.B. Dubey, S. Pareek and Imran Khan
Department of Horticulture, Rajasthan Coleege of Agricuture, MaharanaPratap
University of Agriculture and Technology, Udaipur, Rajasthan-313001*

Abstract

An investigation was carried out at Rajasthan College of Agriculture, MPUAT, Udaipur to assess genetic variability, heritability, genetic advance, correlation and path analysis for yield and yield contributing characters of 16 genotypes of *Valan Kakri* collected from various parts of Rajasthan State. An experiment was laid out in Randomized Block Design with three replications. Significant variations were observed for all the characters in all the genotypes used in the experiment. Highest genotypic and phenotypic variations were observed for acidity of fruit followed by

weight of fruit, total yield per vine, rind thickness and total soluble solids. High heritability with high genetic advance was observed for days to anthesis of first female flower and fruit weight. Total yield per vine was found to be positively and significantly correlated with number of fruits per vine, weight of fruit, diameter of fruit, length of fruit and pulp thickness. Path coefficient analysis revealed that total soluble solids, number of fruits per vine, weight of fruit, number of male flowers per vine and number of seeds per fruit showed positive direct effects on total yield per vine. Among the genotypes, PVK-15, PVK-8, PVK-6 and PVK-3 were found to be higher in total yield per vine, which could be gainfully utilized in further breeding programme.

Studies on Heterosis for Quantitative Traits in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.] in Red and Lateritic Belt of Eastern India

Joydip Mandal and V. K. Dhangraha

*Department of Crop Improvement, Horticulture and Agricultural Botany (CIHAB)
Institute of Agriculture, Visva-Bharati, Sriniketan – 731236*

Abstract

An investigation was undertaken at Horticulture Farm of Institute of Agriculture, Visva-Bharati, Sriniketan during post-*kharif* season of 2011 in red and lateritic belt of West Bengal to estimate the heterosis in 28 hybrids of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] obtained from eight parental lines excluding reciprocal crosses. Heterosis was studied for twelve quantitative characters viz., vine length (m), days to first male and female flower opening, node number to first male and female flower appearance, sex ratio, days to first fruit harvest, fruit weight (g), fruit length (cm) and fruit girth (cm), number of fruits/vine and fruit yield/vine (kg). A wide range of heterosis was observed from negative to positive direction for most of the traits. Significant and desirable heterosis of positive or negative direction was estimated for most of the characters among 28 hybrids. Aditi x Surbhi was considered best performing hybrid as it showed significantly desirable heterosis for early female flowering, early harvesting, number of fruits/vine and fruit yield/vine over better parent, top parent and check variety, respectively. This hybrid gave 98.08% heterosis over better parent, 54.09% over top parent and 47.68% over check variety. So, it may be utilized for commercial exploitation of hybrid vigour.

Evaluation of local germplasm of Bottle gourd [*Lagenaria siceraria* (Mol) Standl] under South Bastar condition of Chhattisgarh

Kamal Narayan¹, H.K. Patra¹ and Deo Shankar²

¹Krishi Vigyan Kendra, Dantewada, IGKV, Raipur; ²S.G college of Agriculture and Research Station, Jagdalpur

Abstract

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.], a monoecious annual climber, is widely grown in South Bastar region as a vegetable crop. It is usually grown in homestead gardens and river bank. A survey was conducted in south Bastar (Dantewada) district of Bastar Zone during the year 2013-14 and collected the bottle gourd accessions. The collected germplasm shown immense variability in the qualitative characters of fruits viz. shape, luster, blossom end, ridges etc. Wide range of variability was recorded in quantitative characters related fruit yield and seed characters. Days to 1st female flower anthesis registered considerable variability, which ranged from 50.3 (DNT-3) to 62.19 (DNT-8). Node number for 1st male flower ranged from 4.01 (DNT-3) to 10.13 (DNT-9), while in case of node number of 1st female flower ranged from 6.31 (DNT-3 to 12.19 (DNT-8). Maximum number of branches per vine (5.8) was recorded in DNT-1 and minimum in DNT-6. The maximum (5.6 Kg) and minimum (0.75 Kg) individual fruit weight was recorded in genotype DNT-5 and DNT-1 respectively. Fruits per vine ranged from 4.20 (DNT-5) to 12.18 (DNT-1). Number of seeds per fruit varied from 231.39 (DNT-2) to 501.3 (DNT-5).

Correlation and Path analysis studies in ivy gourd (*Coccinia grandis*)

T. Maharana, B. Mahapatra and Kaberi Maharana

Orissa University of Agriculture & Technology, Bhubaneswar – 751003

Abstract

Ivy gourd (*Coccinia grandis*) is one of the important vegetables of drier regions of our country. Several land races are grown in different parts of our country. Improved types need to be selected for cultivation. Sixteen genotypes were collected and studied in this trial to assess their genetic variability, through correlation & path

analysis. The present study showed that fruit yield/plant had highly significant positive correlation with fruit length and fruit weight both at phenotypic and genotypic levels. On the basis of path coefficient analysis, it was revealed that the component trait fruit weight had the maximum direct positive effect on fruit yield/plant of ivy gourd which was followed by fruits/plant and fruit length.

Estimation of combining ability for growth, earliness and yield traits in bitter gourd (*Momordica charantia* (L.)

***Mahboob, E. Shashikanth, Chandrakant V. Patil, R. Mulge,
V. D. Gasti, V. Rathod and K. Sumangala***

*Department of Vegetable Science, K.R.C. College of Horticulture,
Arabhavi Tq. Gokak Karnataka,
University of Horticultural Sciences, Bagalkot*

Abstract

An experiment was conducted during 2012-13 at Vegetable Section, department of vegetable science, college of horticulture Arabhavi, on combining ability studies in bitter gourd for quantitative characters by using six lines and four testers in a Line x Tester mating design. Except two characters (number of primary branches and fruit yield per vine) significant differences were observed for the characters under study. Variances due to *SCA* were higher than the corresponding *GCA* for all the characters except for vine length at 60 and 90 DAS, it indicates predominance of non additive gene action and there is a scope for heterosis breeding. Out of ten parents Panurthy, Coimbatore Long, Chidambaram Small and VRBT-100 were observed to be best general combiner as they have made significant contribution in yield contributing characters. Coimbatore Long x Panurthy exhibited high *SCA* effect for fruit yield per vine, node at first female flower appears and days to first harvest, VRBT-100 x Panurthy is best for days to first male and female flower appears, Coimbatore Long x Panurthy is best for sex ratio and number of seeds per fruit in desired direction. These crosses can be exploited as desirable hybrids.

Performance of Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl] in Lateritic Belt of Eastern India

Mangala Tirumalesh and Joydip Mandal

Department of Crop Improvement, Horticulture and Agricultural Botany (CIHAB)
Institute of Agriculture, Visva-Bharati, Sriniketan – 731236 (West Bengal), India

Abstract

Twenty seven diverse genotypes of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] collected from different sources was evaluated during late Kharif season of 2013 in RBD with three replications. The objective of the experiment was to identify suitable genotype(s) of bottle gourd for lateritic belt of West Bengal. Information on different characters viz., node number of first male and female flower, days to first male and female flower opening, vine length (cm), days to fruit harvest, number of fruits/plant, fruit weight, fruit length, fruit girth and yield per plant were collected. Analysis of variance showed highly significant difference among genotypes for all the traits. APBG-3 identified for earliness. Kundan, GolaLattoo, UKBG-1, Pusa Summer Prolific Long (PSPL) and Aditi were identified as good yielder. UKBG-1 and Kundan (more number of fruits, standard fruit weight and high yield per plant) may be suggested for commercial cultivation in lateritic belt of West Bengal.

Quantitative Assessment of Fruit and Seed Characteristics of [*Cucumis melo* subsp. *Agrestis* (Naudin)] Pangalo Germplasm of Central Indian Region

Nilamani Dikshit

National Bureau of Plant Genetic Resources, Regional Station, Akola-444104, Maharashtra

Abstract

Cucumis melo L. subsp. *agrestis* (Naudin) Pangalo is a weedy and feral form of cultivated melon (*Cucumis melo* L.) and has a widespread occurrence in Africa, Asia and Australian continents. In the present paper, an attempt has been made to study the *in situ* diversity of fruit and seed characteristics, occurrence and distribution

pattern of the species, descriptive statistics, correlation, fruit variability and notes on economic uses in 23 accessions of *Cucumis melo* L. subsp. *agrestis* (Naudin) Pangalo germplasm collected from Central Indian. Significant variability was observed among the reproductive traits i.e. fruit length, fruit breadth, fruit weight, seed length, seed breadth and 100 seed weight. High coefficient of variation was observed for fruit weight (38.51 %) followed by seed breadth (19.19 %), fruit length (14.94 %), and fruit breadth (12.29 %) whereas seed length expressed low coefficient of variation (9.43 %). The studies revealed strong correlation between fruit weight with fruit breadth (0.921) followed by fruit length and fruit weight (0.881), fruit length and seed weight (0.683) and seed length and seed weight (0.657). Based on Ward's minimum variance dendrogram, the accessions can be grouped into two main clusters and there is no distinct pattern of geographic relationship among the accessions studied. Principal component analysis explained that the first principal component accounted for the maximum proportion (63.66 %) of the total variability followed by 17.55 % by the second Principal components, third component explain 11.58 % and the fourth only 3.98 % of the variances.

Evaluation of ivy Gourd (*Coccinia grandis* L.) Genotypes grown under Konkan Agroclimatic Conditions

R. R. Patil, P. C. Haldavanekar, Y. R. Parulekar, P. C. Mali and S. B. Thorat

Department of Horticulture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli

Abstract

Ivy gourd (*Coccinia grandis* L.) is an underexploited perennial *Cucurbitaceous* Vegetable crop grown in North Konkan conditions in rice based cropping system. Even though, it is in cultivation since many years, systematic efforts have not been made on improvement of this crop. Considerable genetic variability exists in ivy gourd growing pockets of Raigad district of Konkan region of Maharashtra. Eleven such genotypes were collected and evaluated in Randomized Block Designed in four replications during 2012-2013 to assess comparative performance at Department of Horticulture, College of Agriculture Dapoli, Ratnagiri for 24 growth and yield parameters. The ALG-9 (3.25 days) noticed minimum number of days to harvest form flowering. The highest fruit length and fruit breadth was recorded by ALG-3 (5.75 & 1.81 cm respectively). The highest number of harvest was recorded in ALG-2 (69.75). Similarly, the highest number of fruits, fruit yield per plant (10.24 kg) and yield per hectare (45.50t) was recorded in genotype ALG-2 followed by ALG-3(8.86 kg), ALG-11(8.81 kg), ALG- 4 (8.03 kg), ALG-10 (7.89 kg) and, ALG-9 (7.81 kg).

Studies on identification of sex in spine gourd through SDS-PAGE

M. Rajasekhar, R. Rajyalakshmi and A. V. Subbarao

Horticultural Research Station, Dr. Y. S. R. Horticultural University,
Venkataramannagudem-534101, West Godavari District, Andhra Pradesh

Abstract

The present investigation was taken up at Horticultural Research Station, Venkataramannagudem to determine sex in Kakrol at pre-flowering stage by using molecular methods. Of the 250 seedlings screened, variation was observed among male and female seedlings for different morphological characters and the growth data indicated that the male plants were more vigorous than female plants. SDS-PAGE was used for protein marker identification. Newly emerged leaves from 30 days old plants were collected for analysis. Examination of the protein bands obtained from SDS-PAGE revealed a particular band exclusively present in male plants. Further, studies indicated that the particular protein from male plants had a molecular weight of 14 KDa. Further, sequencing of the 14 KDa protein band is under progress for development of specific primers that may help in identification of male plants at early stages of plant growth.

Hybrid breeding and Seed Protein Electrophoresis in Bottlegourd [*Lagenaria siceraria* (Mol) Standl]

Rakesh Kumar Dubey¹ and Hari Har Ram²

¹Department of Vegetable Science, CHF, CAU, Pasighat, Arunachal Pradesh

²Department of Vegetable Science, GBPUAT, Pantnagar-263145

Abstract

The present investigation was undertaken in bottlegourd (*Lagenaria siceraria* L.) in a half-diallel cross using eight parental lines, namely PBOG 13 (round fruited), PBOG 22, PBOG 54, PBOG 61, PBOG 76, PBOG 117, PBOG 119 and Pusa Naveen (all long fruited). The 36 genotypes (8 parents and 28 F₁'s) were evaluated during Kharif 2003 and summer 2004 for 18 yield and yield related traits. Further, Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE) was performed on eight parental lines to detect protein profile variation in the parental lines. Significant differences were noted among the genotypes for all the traits except pedicel diameter during summer season. Variances due to gca and sca were significant for all characters except fruit weight and pedicel diameter. The relative magnitude of gca variance was

higher than the sca for all the characters except number of seeds per fruit and 100 seed weight indicating the predominance of additive gene action. On the basis of the average gca effect over both the seasons, Pusa Naveen was found to be good general combiner for a set of economic traits eg. days to first male flower (-3.70), days to first female flower (-4.80), node number to first male flower (-1.23), node number to first female flower (-1.24), days to first fruit harvest (-3.34) and pedicel length (-1.81). The other good general combiners were PBOG 76 for main vine length (1.03), number of nodes on main vine (10.70), fruit weight (0.03), fruit length (4.95), pedicel diameter (0.04), number of fruits per plant (1.72) and fruit yield (50.15), PBOG 61 for internodal length (-0.99), PBOG 13 for number of primary branches per vine (3.47) and fruit diameter (1.65). The components of variation indicated that dominance component; H_1 and H_2 were significant for all the characters except days to first male flower while additive genetic variance (D) was significant for all the characters except number of primary branches per vine, fruit weight, pedicel diameter and 100 seed weight suggesting the involvement of both additive and non additive gene action. Vr, Wr graphical analysis indicated involvement of dominant genes for earliness and recessive genes for fruit diameter i.e. the round shape was conditioned by recessive genes. Pusa Naveen and PBOG 13 were indicated as potential donors for earliness and greater fruit diameter respectively. The crosses PBOG 13 x PBOG 61 (495 q/ha) and PBOG 13 x PBOG 76 (468 q/ha) and PBOG 61 x PBOG 76 (443 q//ha) were found to be the best heterotic combinations along with good sca effects for important economic traits and are worth exploiting on commercial scale. A total of 21 bands grouped in four zones were detected in the eight parental lines of bottle gourd. The round fruited cultivar, PBOG 13 had distinguishable protein profile as it lacked A_1 and C_5 which were present in all the long fruited genotypes. PBOG 117 which however was distinguishable from PBOG 13 (round fruited) and PBOG 22, PBOG 54, PBOG 61, PBOG 76, PBOG 119 and Pusa Naveen (long fruited) due to absence of A_2 , A_3 , A_4 , B_3 , B_4 , B_5 , C_1 , C_2 , C_3 , C_4 , D_1 and D_2 bands.

Evaluation of Ivy gourd [*Coccinia grandis* (L.) Voigt.] genotypes of North Eastern Region

J. Saikia, D. B. Phookan, P. Talukdar, A. M. Baruah and K. Baruah

Department of Horticulture, Assam Agricultural University, Jorhat-785013, Assam

Abstract

Ivy gourd [*Coccinia grandis* (L.) Voigt.] (Syn. *C. indica*, *C. cordifolia*) is an underutilized *Cucurbitaceous* vegetable, commonly known as 'Kundru' in Hindi and 'Kunduli' in Assamese. In North Eastern Region, it is cultivated in small pockets, mostly in natural fences. Ivy gourd is a minor but nutritious vegetable having antidiabetic, antioxidant, antibacterial and anti-inflammatory activities. An evaluation trial on ivy gourd genotypes collected from different parts of N.E region was conducted at the

Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, during 2012 and 2013. The experiment was laid out as Randomized Block Design with three replications. Out of 22 genotypes under study, the genotypes IG-20 recorded minimum days to 1st fruit harvest (70.00 days). The highest fruit length and fruit width were obtained by IG-23 and IG-22 respectively and maximum fruit weight was exhibited by the genotype IG-23 (33.00 g). The most promising genotype was IG-23 for maximum fruit yield per plant followed by IG-10 and IG-22. Maturity index of fruit ranged from 6 days to 10 days depending upon the genotypes.

Combining ability and heterosis studies in pumpkin [*Cucurbita moschata* Duon. Ex. Potr.]

Savitha, H.N. Prakash, M. Kumara, B.R. Padamaraj, S.R, and

Shambhulingappa Negalur

College of Horticulture Bagalkot

Abstract

The studies were undertaken to assess *per se* performance, magnitude of heterosis and combining ability in respect of growth, earliness, yield and quality parameters in pumpkin. A line x tester mating design was followed by crossing six lines with three testers to obtain 18 F₁s. These crosses along with their parents and a commercial check hybrid were field evaluated in a randomized block design with three replications during rabi 2012-2013 at College of Horticulture, Bagalkot. Hybrids showed significant differences for all the 26 characters studied. Significant *per se* performance, relative heterosis, heterobeltiosis, standard heterosis and economic heterosis desired directions was observed in most of the crosses. For the yield per vine, nine crosses each over better parent and commercial check hybrid recorded positive heterosis. The promising crosses were BLG-I x IC-276312, BLG-I x CO-2, Dharwad Local x IC-276312 and Arka Chandan x CO-2. The studies on combining ability indicated that GCA variance was higher in magnitude than SCA variance for 10 characters indicating the predominance of additive gene action for number of primary branches, days to first flowering, days to first female flowering, days to fruit maturity, node numbers for flowering and first female flowering, sex ratio, acidity and ascorbic acid content of fruits. For remaining 16 characters, non-additive was found predominant. The pooled gca and sca analysis across the 20 characters indicated Arka Chandan, CO-I, BLG-I, CO-2 and IC-276312 as good general combiners and all the 18 hybrids were found to be most heterotic. Correlation studies revealed that the fruit yield per vine was positively and significantly correlated with vine length, number of primary branches, average fruit weight, fruit diameter, fruit length, flesh thickness, cavity length and width, number of seeds, seed weight per fruit, TSS, carotene content, total sugars and ascorbic acid content of fruits.

Evaluation of F_1 hybrids of watermelon [(*Citrullus lanatus* (Thunb.)] under Konkan agroclimatic conditions

S. M. Sawratkar, Y. R. Parulekar, P. C. Haldavanekar, P. C. Mali and P. M. Haldankar
Department of Horticulture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli

Abstract

Eighteen F_1 hybrids of watermelon were evaluated at Department of Horticulture, College of Agriculture, Dapoli, during 2012-13 in Randomized Block Design used with two replications. All 18 hybrids of watermelon showed wide variation in morphological characters, flowering behaviour, yield and yield attributing characters as well as physical and chemical parameters under study. Among the different growth parameters studied, the highest vine length was recorded by the hybrid Augusta (4.55 m); whereas hybrid NS-295 (5.60) recorded the highest number of branches per vine. The highest number of nodes were noticed in the hybrid Augusta (49.60), whereas, highest inter-nodal distance was recorded in hybrid NWMH-354 (8.03 cm). Regarding the yield and yield attributes, Indam Sumo showed earliness in first harvest (90.00 days). The highest number of harvestings was recorded in hybrid NWMH-354 (4.50) whereas; the highest harvesting span was recorded in hybrid Madhubala (16.5 days). Highest average fruit weight (kg) was recorded by Kashmira (4.200 kg). Maximum number of fruits per vine (2.27), yield per vine (7.966 kg), yield per plot (127.47 kg) and yield per hectare (79.668 t) was observed in Indam Sumo. Highest fruit length (33.5 cm) was recorded in Indam Sumo whereas, the highest fruit diameter was recorded in Kalindi-15 (23.25 cm). Highest T.S.S. was recorded in Honey (13.2 °Brix) and lowest was observed in Kalindi-15 (7.1 °Brix). The hybrid Honey ranked first in the average sensory evaluation score followed by Indam Sumo, Krishna, Black boy, Candy and the score was lowest in Augusta. The hybrid Krishna was superior to all in colour and Honey was superior to all in texture while, Madhubala was superior to all in flavour. The overall observation of different parameters showed that hybrids Indam Sumo, Andaman, Kashmira, NWMH-455, Vigro-286, Black Boy and Shaktiman were found promising for cultivation during Rabi season under Konkan agro climatic conditions.

Relation of biochemical and earliness parameters with the yield of ridge gourd (*Luffa acutangula* Roxb.)

**Shivanand B. Koppad, Mukesh L. Chavan, R. C. Jagadeesha,
Vijaykumar Rathod, Sumangala Koulagi**

Department of Crop Improvement and Biotechnology, Kittur Rani Channamma College of Horticulture, Arabhavi - 591 310

Abstract

Twenty four F_1 hybrids involving four males and six females were produced in ridge gourd in a line x tester design. Bio-chemical and morphological characters contributing to fruit yield were studied. Based on standard heterosis and *per se* performance crosses were identified for fruit yield. The crosses Arabhavi Local x Gadag Local, Kolar Local x Arka Sujata, Arka Sumeet x Arka Sujata and Mudigere Local x Arka Sujata were found to be promising.

Biomass Production and its partitioning in [*Luffa acutangula* (Roxb)]: Impact of physiological traits on fruit yield.

Shivanand B. Koppad, Mukesh L. Chavan, Jagadeesha R. C., Vijaykumar Rathod, Sumangala Koulagi and Rekha H. Hallur
K. R. C. College of Horticulture, Arabhavi 591 218

Abstract

A field experiment was carried out at Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka, to study the influence biomass production and its partitioning in *Luffa acutangula* on the total fruit yield per vine during 2012 - 2014. Statistical analysis of yield data indicated that significantly higher magnitude of SCA variance compared to GCA variance for all the physiological traits indicated predominance of non additive gene action. The genotype Arabhavi local was found to be good general combiner. The crosses Arabhavi Local x Gadag Local (1581.69g), Kolar Local x Arka Sujata (1365.00g), Arka Summet x Arka Sujata (1359.65g) and Mudigere Local x Arka Sujata (1224.48g) have been identified as good specific combiners for fruit yield per vine. AGR of leaf ($11.73 \text{ g} \cdot \text{day}^{-1} \times 10^2$), CGR of leaf ($21.72 \text{ m}^{-2} \cdot \text{day}^{-1} \times 10^2$), NAR of leaf ($0.45 \text{ mg} \cdot \text{m}^{-2} \cdot \text{day}^{-1} \times 10^2$), RGR of leaf ($0.38 \text{ g} \cdot \text{m}^{-2} \cdot \text{day}^{-1} \times 10^2$) and other related traits.

Characterization of muskmelon (*Cucumis melo*) local types of Karnataka for yield attributing traits

Shivapriya Manchali and T. Sudhakara

College of Horticulture, University of Horticultural Sciences, Bengaluru- 560065

Abstract

Muskmelon (*Cucumis melo*, $2n = 24$) is highly polymorphic and plays a significant role in supplying fresh fruits. Different botanical types of muskmelon are commercially cultivated as well as traditionally grown in different parts of our country. The local types of muskmelon are tailored to different agro-climatic regions in Karnataka state and their genetic diversity has not been explored much for crop improvement. In our study, 28 landraces collected from different parts of Karnataka along with two check varieties were characterized using DUS guidelines. Significant genetic variability was observed for most of the traits. The local melons exhibited wide variability for growth parameters, sex forms, fruit characters and some of the fruit quality parameters. This study gives primary information regarding the genetic diversity existing among local muskmelon lines of Karnataka that could be utilized in crop improvement programme as well as conservation of germplasm.

Evaluation and Identification of Ash gourd [*Benincasa hispida* (Thunb.)Cogn.] entry as KAG-1(Azad Petha-1)

I.N. Shukla, P.K. Tiwari and U.C. Misra

Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur-208 024 (UP)

Abstract

Ash gourd is known as pethakaddu widely cultivated in India and several tropical countries. It is especially grown in North India and used in the preparation of several types of petha sweets all over India. Ash gourd is an extensive trailing or climbing annual herb having cylindrical or spherical shape fruits covered with bluish white waxy ash. The fruits have long shelf life. Keeping in view a variety of ash gourd as KAG-1(Azad Petha-1) was identified in AICRPVC trials at different centers during 2007-08, 2008-09 and 2009-10. The data was thoroughly scrutinized by the committee to evaluate the performance of promising lines from various centers for identification of entries for release. During 2007-08 ash gourd trial as IET was conducted at 11 centers using IVAG-90 and PAG-72 as standard checks. At Pantnagar only entry KAG-1 found superior over checks with an yield of 670 quintal per hectare whereas during 2008-09 and 2009-10 under AVT-I and AVT-II KAG-1 was also found superior over other entries at Vellanikara, Pondicherry, Coimbatore and Faizabad over checks and second at Hyderabad and Kalyani.

Variability, co-relation and path analysis studies in ivy gourd [*Coccinia grandis*(L.) Voigt]

D. N. Singh, B. Jha and P. K. Bhanja

*College of Agriculture, Orissa University of Agriculture and Technology,
Bhubaneswar-751003*

Abstract

Eighteen genotypes of Ivy gourd were assessed for variability, co-relation and path analysis for yield and its attributes. The difference among genotypes were statistically significant for all the thirteen characters. High estimates of genotypic co-efficient of variation, heritability and genetic advance were shown by number of primary branches/plant and number of fruits per plant respectively. Co-relation studies among the fruits indicated that number of fruits/plant had high positive co-relation with fruit yield at both phenotypic and genotypic level. Path analysis for fruit yield revealed that number of fruits/plant, primary branches, leaf area, vine length, days to first harvesting and fruit weight had high to moderate direct effect on yield.

Heterosis and combining ability studies in bitter gourd (*Momordica charantia* L.)

Sridhar, Prakash, M. Kumara, B.R. Savitha H.N. And Siddappa Madarkhandi
College of Horticulture, Arabhavi

Abstract

Investigation on "Heterosis and combining ability studies in bitter gourd (*Momordica charantia* L.)" was undertaken during 2011-2012, in Department of Vegetable Science of Kittur Rani Channamma college of Horticulture, Arabhavi. The study was mainly contemplated to find out best cross combinations and to find out the best general and specific combiners for higher yield. The entries under the investigation comprised five lines (DWD-2, IC-85619A, PRD-2, IC-85614 and Green long) and five testers (White long, NRN-1, BLG-1, PRD-3 and PRD-5) resulted from germplasm collection on the basis of *per se* performance for yield and quality attributes in the experiment and mated in line x tester method. Twenty five hybrids were generated and evaluated along with ten parents and a commercial check (MBTH-101) during summer 2012. Wide range of heterosis was manifested by the twenty five F₁'s for almost all the characters. Green long x PRD-5, DWD-2 x PRD-5 and IC-

85619A x NRN-1 were high yielders with the yielding potentialities of 2.53, 2.35 and 2.26 kg fruits per vine, respectively, with heterosis of 25.43, 16.51 and 12.05 per cent over commercial check. Green long x PRD-5 and IC-85619A x NRN-1 were good specific combiners and green long, PRD-5 and IC-85619A were the best general combiners for higher yield. The crosses Green long x PRD-5, DWD-2 x PRD-5, IC-85619A x NRN-1 and IC-85614 x PRD-3 were found to be moderately resistant for both fruit fly and downy mildew incidence. From the results it can be concluded that Green long x PRD-5, DWD-2 x PRD-5 and IC-85619A x NRN-1 which have shown higher potentialities for yield. Therefore these crosses need to be commercially exploited.

Correlation and path-coefficient analysis in muskmelon (*Cucumis melo* L.)

Tejbir Singh, V. K. Vashisht and Nirmal Singh

*Department of Vegetable Science, Punjab Agricultural University,
Ludhiana-141004*

Abstract

Present study was conducted to assess the nature and magnitude of association among fruit yield and its contributing traits in muskmelon. The study comprised 45 muskmelon hybrids which were evaluated for days taken to first female flower opening, days taken to first fruit ripening, number of fruits per vine, fruit weight, total fruit yield per vine, polar diameter of fruit, equatorial diameter of fruit, flesh thickness, rind thickness, fruit cavity area, TSS content, vine length and resistance reaction to *Fusarium* wilt, Cucumber Mosaic Virus and downy mildew. Studies revealed that total fruit yield per vine had significant and positive association with number of fruits per vine, fruit weight, polar diameter of fruit, equatorial diameter of fruit, flesh thickness, fruit cavity area, TSS content, vine length and resistance reaction to *Fusarium* wilt. However, its significant negative correlation was observed with days to first fruit ripening. Path coefficient analysis inferred that number of fruit per vine followed by fruit weight, polar diameter of fruit, equatorial diameter of fruit, flesh thickness, fruit cavity area, vine length and resistance reaction to *Fusarium* wilt and downy mildew had maximum direct effect on total fruit yield per vine. Hence, preference for higher number of fruits per vine, fruit weight and disease resistance to *Fusarium* wilt may be used as selection criteria in muskmelon.

Evaluation of F_1 hybrids in Oriental pickling melon for yield and quality attributes

G N. Thyagaraj, M. Prakash, B. R. Kumara, S. R. Padmaraja and N. Santhosh

Division of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru -560 065

Abstract

Oriental pickling melon is one of the melon group vegetable of the *Cucurbitaceae*. Present field experiment was carried out at Department of Horticulture, GKVK, UAS, Bengaluru during the year 2010-2011 to evaluate 25 Oriental pickling melon F_1 hybrids for yield and quality. The F_1 hybrid CMC GKVK 1 x CMC GKVK 2 have shown better performance for characters such as fruit length and fruit diameter, while the F_1 hybrid CMC GKVK 2 x CMC GKVK 4 performed well for other characters such as per cent fruit set, number of fruits and total fruit yield per vine. However, the fruit flesh thickness and total soluble solids where high with the F1 hybrid CMC GKVK 1 x CMC GKVK 12. Finally it can be inferred that among the F1 hybrids CMC GKVK 2 x CMC GKVK 4, CMC GKVK 1 x CMC GKVK 2, CMC GKVK 5 x CMC GKVK 8 and CMC GKVK 9 x CMC GKVK 2 were high yielding. For the purpose of processing F_1 hybrids CMC GKVK 1 x CMC GKVK 12, CMC GKVK 7 x CMC GKVK 9, CMC GKVK 1 x CMC GKVK 2 and CMC GKVK 2 x CMC GKVK 4 were suitable.

Mean performance of gynoecious F_1 hybrids for horticultural characters in cucumber (*Cucumis sativus* L.)

Yudhvir Singh, Madhu Sharma, Akhilesh Sharma and Arti Verma

CSK HPKV Palampur-176062

Abstract

Genetic improvement of crop plants is a continuous process and the plant breeders continuously strive for developing new varieties, which are high yielding and superior to the existing ones. Field experiment was conducted at the Research Farm, Department of Vegetable Science and Floriculture, CSK HPKV, Palampur and Hill Agricultural Research and Extension Centre Bajaura, Kullu valley during kharif season with an objective to find out the most suitable hybrid interms of yield and its related

traits of cucumber for commercial cultivation. Fifty five cucumber hybrids were evaluated for yield and yield related traits in RCBD with three replications. The study revealed that the hybrid G-1 × K-pap was early in flowering (21.32 days) and days to first fruit picking (30.00) while the highest fruit length (21.97cm) and vine length (2.98m) was observed in the hybrid Plp × JLG. The hybrid PCUCP-4 × KL-3 for fruit girth (5.28cm); EC-5082 × KL-3 for average fruit weight (245.26g); G-3 × K-pap for harvest duration (53.46) and G-1 × K-75 for number of primary branches (4.00) had higher values. The result suggests that combinations viz. G-3 × Sel-75-2-10, Plp × K-pap and EC-5082 × EC-173934 showed better performance for marketable yield per vine thus can be commercially exploited as F₁ hybrids or for deriving improved lines for yield.

Heterosis studies for yield and its related components by involving gynoecious lines in Cucumber (*Cucumis sativus L.*)

Yudhvir Singh, Madhu Sharma and Arti Verma

Department of Vegetable Science and Floriculture, CSK HPKV, Palampur-176062

Abstract

Exploitation of hybrid vigour depends on the direction and magnitude of heterosis, biological feasibility and type of gene action involved. The present investigation was undertaken with a view to examine the manifestation of heterosis in cucumber. Heterosis studies involving gynoecious lines in cucumber (*Cucumis sativus L.*) was carried out at the Experimental Farms of the Department of Vegetable Science and Floriculture, CSK Himachal Pradesh KrishiVishvavidyalaya, Palampur and Hill Agricultural Research and Extension Centre, Bajaura, Kullu to assess the magnitude of heterosis for yield and its contributing characters, following line x tester mating design .and analysis. Analysis of variance indicated significant differences among treatments for all the characters studied viz. days to first female appearance, nodal position of first female flower, days taken to first picking, fruit length, fruit girth, average fruit weight, marketable fruit per vine, marketable yield per vine, harvest duration, number of primary branches, vine length and total soluble solids under pooled over environments thereby revealing the presence of sufficient genetic variability in the experimental genetic material. There was wide variation in magnitude and direction of heterosis for all characters. Marketable yield per vine, marketable fruits per vine and average fruit weight were the most heterotic characters. Appreciable heterosis over better parent and standard checks (Solan Khira Hybrid-1 and Pusa Sanyog) was observed for almost all the traits. For marketable yield per vine 50 cross combinations in pooled environment showed hybrid vigour over better

parent. The hybrid vigour was mainly on account of increased, fruit number, weight and size. The cross combinations viz., EC-5082 × SG, EC-5082 × Sel-75-2-10, and G-1 × K-pap, exhibited maximum heterosis for earliness. Based on hybrid vigour, vis-à-vis their mean performance and from consumer view point, the combination Plp-Gy-1 × K-pap, Plp-Gy-1 × K-90, G-1 × Summer Green, G-1 × K-pap and G-3 × Sel-75-2-10 were the most promising one and can be exploited for commercial production.

Correlation and path analysis studies in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]

K. G. Janaranjani, V. Kanthaswamy and B. Muralidharan

Pandit Jawaharlal Nehru College of Agriculture and Research Institute (TNAU), Karaikal-609603 (U.T of. Puducherry)

Abstract

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] belongs to the family *Cucurbitaceae* having chromosome number $2n = 22$. Bottle gourd is a valued vegetable for its nutritive and medicinal properties. Its tender fruits are used as cooked vegetable and also for making sweets in Africa and Asia. The dried fruits are used as containers, utensils, fishing floats and some musical instruments. The present investigation was carried out at the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during 2011 and 2012. Genotypic correlation coefficient provides a measure of genotypic association between the characters and reveals the characters that might be useful as an index of selection. This also helps to decide the dependability of the characters that have little or no character could be hurtful for proper choice of parents for hybridization programme. The path analysis facilitates the partitioning of correlation coefficients into the direct and indirect effects of component characters on yield and any other attributes. Keeping in this view, the present investigation was conducted to determine the characters and their direct and indirect effects on yield. An experiment was conducted with 18 different characters viz., vine length, number of primary branches, node at first male and female flower appears, days to first male and female flower opening, sex ratio, days to first fruit harvest, fruit length, fruit cavity, fruit flesh thickness, fruit width, fruit weight, number of fruits per vine, number of pickings, number of seeds per fruit, 100 seed weight and yield per vine. It is comprising 36 hybrids obtained by crossing 9 lines and 4 testers by Line × Testers method to study the correlation and direct and indirect effects of different characters on fruit yield in a randomized block design. Fruit flesh thickness, number of fruits per vine, number of pickings showed significant positive association with fruit yield per vine, while sex ratio, fruit length, fruit width, fruit cavity, fruit weight, 100 seed weight showed positive non-significant association with fruit yield per vine. Node at first male flower

appears showed significant negative association with fruit yield per vine. Vine length, number of primary branches, node at first female appears, days to first male flower opening, days to first female flower opening, days to first harvest, number of seeds per vine recorded negative non-significant correlation with fruit yield per vine. Number of fruits per vine recorded highest correlation ($r = 0.676$) followed by number of pickings ($r = 0.415$) and fruit flesh thickness ($r = 0.381$). The result of path analysis indicated that highest positive direct effect on the fruit yield per vine was exerted by number of fruits per vine (0.9156) followed by days to first female flower opening (0.800), fruit cavity (0.38096), fruit weight (0.37378), days to first harvest (0.19179) while selecting a good hybrids for enhancing the yield of bottle gourd.

Studies on Heterosis in bottle gourd (*Lagenaria siceraria* (Mol) Standl)

K. G Janaranjani, V. Kanthaswamy and B. Muralidharan

Pandit Jawaharlal Nehru College of Agriculture and Research Institute (TNAU),
Karaikal-609 603

Abstract

Bottle gourd is a valued vegetable for its nutritive and medicinal properties. Its tender fruits are used as cooked vegetable and also for making sweets in Africa and Asia. Nine lines and four testers and 36 F_1 hybrids of bottle gourd obtained from L x T mating, were studied to investigate the extent of heterosis for yield and its contributing characters during 2011 and 2012 in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry. The variety NDBG-164 was used as the standard check variety to estimate the standard heterosis. Negative heterosis was observed for the eight characters studied viz., node at first male flower appearance node at first female flower appears, days to first male flower opening, days to first female flower opening, days to first fruit harvest, fruit cavity, 100 seed weight and number of seeds per fruit in respect to the yield while positive heterosis was considered to be desirable for the remaining 10 traits viz., vine length, number of primary branches, sex ratio, fruit length, fruit width, fruit flesh thickness, number of fruits per vine, number of pickings, fruit weight and yield per vine. The heterobeltiosis for yield per vine was positive and significant in 36 hybrids. The maximum positive and high significant heterotic expression of 133.61 per cent for fruit yield per vine, number of fruit pickings and fruit length was observed in Pusa Naveen x NDBG-164 ($L_7 \times T_2$) followed by Pusa Naveen x Punjab Komal ($L_7 \times T_1$) with heterotic expression of 132.31 per cent for fruit yield per vine. Therefore, it is concluded that Pusa Naveen x NDBG-164 and Pusa Naveen x Punjab Komal, could be considered for commercial cultivation as F_1 hybrids after conducting confirmatory trials (MLT and ART) in farmers field .

Genetic Diversity analysis in Snap melon (*Cucumis melo L. var momordica*) through Biometrical techniques and SDS-PAGE

V. R. Muddarasu, Rakesh Kr Dubey, Vikas Singh,

V. B. S. Chauhan and A. K. Pandey

College of Horticulture & Forestry, CAU, Pasighat, Arunachal Pradesh

Abstract

The present investigation was conducted during summer 2012 at Vegetable Research Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh in 20 diverse genotypes of Snap melon. The experiment was laid out in randomized complete block design with three replications. Genetic variability was studied for attributes viz., days to 50% germination, vine length, number of primary branches, days to first staminate flower anthesis, days to first pistillate flower anthesis, days to first harvest, fruit length, fruit diameter, fruit weight, flesh thickness, number of fruits per plant, number of seed per fruit, TSS, ascorbic acid, titrable acidity and fruit yield per plant. Data were analyzed statistically for phenotypic and genotypic variance, coefficient of variation, heritability, genetic advance, genetic gain, correlation coefficient, path coefficient, genetic divergence and seed protein banding pattern. Analysis of variance revealed significant differences among the genotypes for all the attributes. The genotypes CHFSM-5, CHFSM-10 CHFSM-11 and CHFSM-15 were found to be superior for the most of the yield components and fruit quality traits. High PCV and GCV, heritability, genetic gain were observed for Days to 50% germination, fruit length, fruit weight, flesh thickness, number of fruit per plant, number of seed per fruit, TSS, ascorbic acid, titrable acidity and fruit yield per plant. Correlation studies indicated that fruit yield per plant was positively and significantly correlated with vine length, number of primary branches per vine, fruit length, fruit diameter, fruit weight, flesh thickness, number of fruits per plant, and number of seed per fruit however negative and significant association was established with TSS and titrable acidity. Maximum positive direct effect on fruit yield per plant was imposed by TSS, number of seed per fruit, flesh thickness, fruit weight and fruit length which were observed as the most important traits affecting fruit yield per plant, However, high negative direct effect was observed for days to first staminate flower anthesis, number of fruits per plant, and days to first pistillate flower anthesis. Divergence study revealed that ascorbic acid content contributed maximum percent to diversity followed by titrable acidity, fruit yield per plant, number of seed per fruit, and TSS. Maximum inter cluster distance was observed between cluster 4 and 5 and indicated that the genotypes within these

were highly divergent. SDS-PAGE analysis showed a total of 54 bands identified by coomassie brilliant blue staining. The genotypes exhibited considerable variation in protein band number ranging from 19-31. Among the genotypes CHFSM-1 and CHFSM-8 showed maximum number (31) of protein bands while the minimum numbers (19) of bands were present in CHFSM-2, CHFSM-11, CHFSM-12 and CHFSM-17. It was evident from the present investigation that the genetic relationship study utilizing SDS-PAGE analysis enhanced the resolution of diversity and thus provided a better portrait of variability as compared to morphological markers.

Character association analysis studies in Bottle gourd [*Lagenaria siceraria*(Mol.)Standl]

B. Muralidharan, V. Kanthaswamy and B. Sivakumar

Pandit Jawaharlal Nehru College of Agriculture and Research Institute (TNAU), Karaikal, U.T. of Puducherry.

Abstract

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] is an important member of family *Cucurbitaceae*. It is commercially grown in almost all parts of India during summer as well as rainy season, the fruits are nutritionally rich and used in various culinary purposes. Yield is a complex character and is governed by polygenic system. Moreover, it is highly influenced by environmental fluctuations. Correlation analysis helps in the evaluation of relationship existing between yield and its components along with the inter relationship among the yield components. Phenotypic correlation is the observable correlation between two variables, which includes both genotypic and environmental effects. Genotypic correlation on the other hand is the inherent association between two variables and it may be either due to pleotropic action of genes or linkage or both. Environmental correlation arises entirely due to environmental effects. Path analysis permits the separation of direct effects from indirect effects through other related traits by partitioning the genotypic correlation coefficients Dewey and Lu, (3). Investigation on the evaluation of bottle gourd genotypes for yield was carried out in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Coastal region of Karaikal, U.T. of Puducherry from January to March 2011. The twenty four diverse genotypes were evaluated for *per se* performance, phenotypic and genotypic variability, heritability genetic advance and genetic divergence. The association and contribution of different characters towards yield were also estimated for all the twenty four genotypes for 19 characters. All the accessions were evaluated for nineteen characters viz., vine length, number of primary branches, node at which first male flower appears, node at which first female flower appears, days to first male

flower anthesis, days to first female flower anthesis, sex ratio, days to first harvest, fruit length, fruit width, fruit cavity, flesh thickness, fruit weight, number of fruits per vine, number of pickings, number of seeds per fruit, weight of 100 seeds, yield per vine and total soluble solids. The yield per vine was found to be significant and positively correlated with fruit flesh thickness and fruit weight. Number of primary branches, sex ratio, fruit length, fruit width, fruit cavity, number fruit per vine, number of pickings and number of seeds per fruit were recorded positive and non-significant association with fruit yield per vine. Vine length, node number at first male flower appearance, node number at first female flower appearance, days to first male flower anthesis, days to first female flower anthesis, days to first harvest, weight of 100 seeds, and total soluble solids showed negative and non-significant association with yield per vine. Fruit weight recorded highest correlation ($r = 0.644$) with fruit yield per plant followed by fruits flesh thickness ($r = 0.522$) at genotypic level. The results of path analysis showed direct and indirect effect of eighteen contributing characters to yield per vine. Association of characters also indicated the highest contribution of fruit weight and fruit flesh thickness towards yield. The path analysis studies revealed the highest direct effect of fruit weight, fruit width, number of seeds per fruit, days to female flower anthesis, number of fruit per vine, fruit flesh thickness, number of primary branches and number of pickings on fruit yield.

Studies on heterosis and combining ability in ridge gourd [*Luffa acutangula* (L.) Roxb.]

Prakash, M. Kumara, B.R. Savitha H.N. Padamaraj, S.R. And Shambhulingappa*Negalur, College of Horticulture, Bagalkot*

Abstract

Heterosis and combining ability for yield and component characters in ridge gourd were undertaken by adopting half Diallel analysis during *kharif* at Kittur Rani Channamma College of Horticulture, Arabhavi. A total of six parents and 15 hybrids along with commercial check were evaluated in Randomized Block design with three replications during 2011-2012. Observations were recorded on 22 growth and yield characters. The analysis of variance revealed that 16 of the 22 characters were significant for treatments (genotypes). Heterosis results revealed that the cross ($P_1 \times P_6$) (73.62%) exhibited maximum heterobeltiosis and significant positive heterosis over commercial check for early yield per vine. For total yield per vine the cross $P_2 \times P_5$ exhibited maximum heterosis over mid parent and better parent and also exhibited 5.79 per cent heterosis over commercial check. For days to first flowering, first female flowering and first harvesting 12, 5 and 7 hybrids, respectively exhibited significant negative heterosis. Four hybrids showed significant positive

heterobeltiosis for fruit length and diameter and only two hybrids exhibited significant heterobeltiosis for average fruit weight. Combining ability results revealed that both GCA and SCA variance were Significant for 13 of the 16 traits studied. But for number of early, late and total fruits per vine only SCA variances were significant indicating the predominance of non-additive gene action for these traits. Overall analysis for combining ability results indicated that Arka Sujat, RCR-1 and Selection 4-12 very good general combiners for most of the traits. Results of correlation studies revealed that yield per vine was positively and significantly correlated with average fruit weight, early yield, number of fruits, fruit diameter, fruit length and number of leaves per vine. Early yield per vine had positively and high direct effect on total yield per vine.

Genetic variability, Character association and Path coefficient analysis in Ridge gourd under foothills of Himalayas

**Uzma Khatoon, Rakesh Kr Dubey, Vikas Singh, VBS Chauhan,
SD Warade and A K Pandey**

College of Horticulture & Forestry, CAU, Pasighat, Arunachal Pradesh

Abstract

This study was conducted during summer 2013 at Vegetable experimental farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh in 40 ridge gourd genotypes collected from different part of India to estimate the magnitude of genetic variability and character association among yield characters. Analysis of variance revealed significant differences among the genotypes for all the attributes. The genotypes CHFRG-10, CHFRG-22, CHFRG-28 and CHFRG-30 were found to be superior for the most of the yield components and fruit quality traits. High PCV and GCV, heritability, genetic gain were observed for vine length, number of node per vine, number of node to first pistillate flower appearance, pedicel length, fruit length, number of fruit per plant, and yield per plant. Correlation studies indicated that fruit yield per plant was positively and significantly correlated with vine length, number of node per vine, crop duration, fruit length, fruit diameter, number of fruit per plant and average fruit weight. However, negative and significant association was established with days to first staminate flower anthesis and pistillate flower anthesis. Maximum positive direct effect on fruit yield per plant was imposed by number of fruit per plant, vine length, average fruit weight, fruit length, days to first staminate flower anthesis, days to first pistillate flower anthesis and days to 50% emergence which were observed as the most important traits affecting fruit yield per plant. However, high negative direct effect was observed for number of node per vine, internodal length and fruit diameter.

SESSION III

ADVANCES IN PRODUCTION TECHNOLOGY OF CUCURBITS

Techniques and prospects of Protected Cultivation of Cucurbits in India

Balraj Singh

National Research Centre on Seed Spices
Tabiji, Ajmer, Rajasthan-305206

Abstract

The basic reason behind the lower productivity and poor quality in cucurbits is mainly due to the damage caused by several biotic and abiotic stresses under their open field cultivation. Among the major abiotic stresses extreme of temperature in both sides (i.e. maximum and minimum) prevailing in several cucurbits growing parts of the country, extreme of relative humidity (i.e. maximum and minimum), extreme of radiation (i.e. maximum and minimum), dust storms, hail storms and upto some extent problematic soils like saline and acidic soils creates problems for their successful cultivation and affects not only the productivity but these abiotic stresses which ultimately also reduces the quality of produce. Among the biotic stresses large number of viruses are mainly responsible for severe damage to different cucurbits and the intensity of infestation is more severe during the rainy and post rainy season in different parts of the country under their open field cultivation. Other than viruses the other biotic stresses viz., important fungal and bacterial diseases, nematodes, large number of insects and pests like fruit fly, leaf miner, red pumpkin beetle, leaf eating caterpillars, aphids and mites are also responsible for lower productivity and poor quality in cucurbits.

Not only this traditional methods of cultivation like flatbed cultivation, direct seeding, surface irrigation, growing the cucurbitaceous crops on ground in horizontal way, serious plant weed competition, traditional methods of fertilizers application or imbalanced use of fertilizers and very poor knowledge about crop management particularly about timely and effective plant protection techniques are the other reasons which are also equally responsible for lower productivity and poor quality. But by using the modern methods of cucurbits cultivation, these all above mentioned problems in terms of biotic and abiotic stresses can be solved upto a great extent and both the productivity and quality can be enhanced upto a higher level. Several production technologies/agro techniques, e.g. raised bed technology, training and pruning IPM, plug tray nursery raising technology, low cost off season protected cultivation technology, greenhouse crop production technology and hybrid seed production techniques, have been developed and standardized for different cucurbits for different regions with the aim to improve the productivity of these crops on a sustainable basis.

Hi-Tech production technologies for cucumber and melon cultivation

M. Prabhakar, S. S. Hebbar, A. K. Nair, R. S. Rajeshwari and K. Bharathi

*Division of Vegetable Crops, Indian Institute of Horticultural Research,
Hesarghatta Lake P.O., Bangalore, Karnataka-560089*

Abstract

In India vegetables are grown on an area of 9.21 million hectare with a production of 162.19 million tonnes and the productivity of 17.62 t/ha. It ranks second in the vegetable production after China in the world but stands comparatively lower in productivity than major vegetable producing countries. The country's present annual requirement is 175.2 million tonnes in vegetables, but considering the post-harvest losses, 210 million tons of vegetables have to be produced. With the present level of population, the annual requirement will be of the order of more than production level. India plans to increase the production of vegetable crops to 340 million tonnes by 2050 from present level of production to feed its ever growing population. If India has to emerge as an economic power in the world, our agricultural productivity should equal to those countries, which are currently rated as economic power of the world. We need new and effective technologies which can improve continuously the productivity, profitability, sustainability of our major farming systems. One such technology is the hi-tech vegetable growing technology which includes various components of precision farming in open as well as under protected cultivation. These technologies will augment higher productivity with quality and also facilitates round the year supply of the produce. Among the vegetables, cucurbits and melons have important role in Indian diet for its nutrition values and in Indian horticulture for increased farm income. The productivity of cucumber (15.67 t/ha), musk melon (20.67 t/ha) and water melon (22.20 t/ha) is low in India due to non-adaptability of advanced production technologies, whether grown in uplands or river beds. As stated above, the hi-tech cultivation of these crops not only increases the production of these crops but also availability during the off seasons. Field experiments were conducted during 2008-2014 in water melon and slicing cucumber at the farm of Indian Institute of Horticultural Research, Bangalore. The results of the experiment on *Rabi* summer grown watermelon shown that application of water soluble fertilizer @ 70:70:70 kg N:P:K per hectare through fertigation resulted in significantly superior values for the crop growth characters such as vine length, number of branches per plant and

leaf area index. The results also indicated that irrespective of the source and doses, fertigation treatments recorded higher average marketable water melon yield over the soil application of conventional fertilizers to the tune of 7.3 to 26.4 per cent. The economics of fertigation treatments revealed that for enhancing productivity of water melon, water soluble fertilizers are better, however due to their higher cost from the net income point of view fertigation using conventional fertilizers was found more economical. The experimental results from the slicing cucumber grown in open field during summer have indicated that the drip fertigation using either conventional or water soluble fertilizers resulted in better growth and yield (46.3-55.13 t/ha) as compared to soil application of conventional fertilizers (37.5 t/ha). In fertigation treatment further improvement in crop productivity was observed with polyethylene mulching. Studies on greenhouse cultivation of musk melon and European cucumber using naturally ventilated poly house at IIHR, Bangalore were carried out during 2006-2011. The results clearly indicated that not only the higher productivity and quality, even the produce can also be harvested during off season. Several cultivars of musk melon viz., Punjab Hybrid, Punjab Sunheri, Punjab Anmol, NS- 10, Madhuras, Pusa Madhuras, Kashi Madhu, Bobby, Swathi and Sun were grown during winter months with sowing dates extending from October to November. The average fruit yields of the green house grown crops was substantially higher (60.7 t/ha) as compared to open field crop (29.4 t/ha). Fruit quality characters like fruit size and TSS were significantly superior in green house crop compared to open field. The green house studies were also conducted for off season (winter) production of cucumbers inside the green house. Several varieties belonging to regular slicing (Malini, Tripti, Rajdhani, Green long, PS Kheera, US-6125 and NS 404) and parthenocarpic cucumber (I-Satis, Valley star and Silyon,) types were tested. The studies have indicated the possibility of harvesting period of about 75-80 days facilitating about sixteen harvests at an interval of five days. The average yield of three years with regular slicing cucumber hybrids was in the range of 84.9 to 117.4 tonnes per hectare, while in parthenocarpic cucumbers yield ranged from 112.0 to 114.3 t/ha. Though the yield levels with parthenocarpic cucumbers were marginally lowers, but due to their higher market price, they resulted in higher economic returns. Parthenocarpic cucumbers did not require pollination, whereas regular slicing cucumbers were hand pollinated. From these studies it is clearly evident that hi-tech production technologies such as open field precision farming and green house cultivation will play a major role in enhancing the crop productivity, produce quality, high economic returns per unit area and facilitate off season or year round production of cucurbitaceous vegetables.

Status and future scope for soil and nutrient management for sustainable production of cucurbits

A. N. Ganeshamurthy

Indian Institute of Horticultural Research,
Hessaraghatta Lake Post, Bengaluru 560089

Abstract

Despite the continued development of new and improved modern varieties and greater use of chemical fertilizers, yield growth began to slow in the latter part of the 20th century. Farmers often apply fertilizer in excess of recommended levels in order to ensure high yields. Concern has also grown in recent years that the use of fertilizers, particularly inorganic fertilizers, can lead to serious environmental consequences. Environmental contamination of this type, however, is largely a problem in the developed world and a few regions of the developing world.

Cucurbits are a group of plants belonging to cucurbitaceae family with the most species used as human food. Within this family, the genus *Cucurbita* stands out as one of the most important. Five of its species have been domesticated in the New World and for thousands of years they have been cultivated. In spite of the current marginalization of some of these species, from very remote times all have contributed essential food products to the diet of human beings.

Cucurbits come on all types of well drained soils. The performance of crops is directly related to the organic carbon status of the soil as these crops do not tolerate nutrient imbalance in the system. The fertiliser requirements of cucurbits as a group are not particularly high. The nitrogen requirement is about 75 kg to 100 kg per hectare. Phosphorus 35 to 50 kg per hectare and potassium 80 to 100 kg per hectare. If not under fertigation half to two-thirds of the nitrogen, and all the phosphorus and potassium, are applied at planting, with the remaining nitrogen being applied 3 to 4 weeks after emergence. Cucurbits suffer severely from boron, molybdenum and zinc deficiencies in large areas. Foliar spray of boron alone has resulted in significant improvement in yield, shape and size of fruits in most of the cucurbits. Where molybdenum is known to be deficient, seed soaking is recommended for 4 to 6 hours in a solution of 15 g to 20 g sodium or ammonium molybdate in 5 litre water. The soaking also encourages rapid

germination. Foliar spray of micronutrient formulations containing multiple micronutrients have shown promising results in many locations.

Though the crops are highly water efficient, to encourage deep rooting the soil should, during the first third of the growing period, be wet to a depth of 450 mm, whenever 90% of the available soil moisture has been depleted. Later part the crop performs well even at 50% depletion Cucurbits find a prominent place in greenhouse crops even though they cover a small fraction of total cultivated cucurbits. But they do play an important role in producing high quality and off season crops. Crops are often concentrated in relatively small areas in periurban clusters. However in periurban areas production comes with potential consequences on the environment due to the discharge of waste materials (e.g. heavy metals, organic pollutants, plastics and artificial growing media) and the large use of water and agrochemicals. Awareness of the pollution associated with open and greenhouse cropping systems in periurban areas need to be created.

Recent advances in production technology of cucurbitaceous vegetables

Dr. B. K. Srivastava

Ex-Professor, Vegetable Science, G B. P. U. A. T. Pantnagar

Abstract

Among different group of vegetables, cucurbits are the largest one having 15 vegetables under commercial cultivation and about 7 confined to homestead or hut gardens. In the world, maximum area is occupied by watermelon, whereas in India pumpkin, squashes and gourds predominate the cultivation. F.A.O. estimates indicate that productivity of most of the cucurbits in India is even lower than the world average. Besides the huge market available in the country itself, many cucurbits are also in demand from abroad. Hence, it warrants to make every effort to boost the productivity by genetic improvement as well as by agronomic and pest management strategies.

One of the recent advances in production technology of vegetables, including cucurbits, has been the area of plasticulture. To reduce the cost of production with ensured establishment of transplants in the field, the seedlings are being raised in trays specially in poly greenhouses. The growing

media consisting of vermiculite/ perlite / geolite / cocopeat / compost/ FYM/ rock wool/ sand / soil mixed in appropriate proportion filled in potting plugs also called as plug trays or protrays facilitates the sprouting of seeds, development of healthy seedlings, easy uprooting of seedlings along with small earth ball, finally leading to a better field establishment. In traditional riverbed cultivation in north India, the farmers take a lot of trouble to rear the plants during severe winter with the interest to get early crop in spring season. The poly house/ low tunnel nursery production can tremendously save the time and money of such farmers without sacrificing the benefit of taking early off season crop. Cucurbits are basically warm season vegetables grown as *kharif* and *zaid* crops in northern plains. The protected cultivation has made it possible to produce them year round. The vegetables like cucumber, gherkins, bitter gourd, and bottle gourd have successfully been grown during winter season in low cost naturally ventilated poly house. In mid hills and valleys, also melons may be produced during summer season. The experiments have revealed that compared to the open field, manifold increase in the yields of different cucurbits may be achieved using low cost poly green houses. Eco-friendly plant protection has also been achieved through plastic application. Solarization of nursery bed or small field soil using plastic film has been found very effective in minimizing the attack of soil borne pathogens. Similarly, transparent poly ethylene sleeves having both ends open with 30-45 cm height and 120 cm circumference if installed over the hills have proved even better than insecticidal application in the control of red pumpkin beetle in early growth stage ,as observed at Pantnagar.

Since cucurbits are planted at comparatively larger distance ,the drip system of irrigation is found more economical than closely planted many other vegetables .Experiment conducted at several locations across the country have shown an increase in the range of 11-200 % in the yield of various cucurbits with a water saving of up to 68% .Now a days ,low gauge stable plastic films are available which have also proven their worthiness in improving the yield ,economizing the irrigation cost and exhibiting many other beneficial effects .Site specific application of water and the nutrients are the essential components of the much talked about precision farming .However, more studies are needed in this area and the operations are made to be more handy .Root distribution studies in cucurbits have not been done in our country .Such studies will be helpful in site specific nutrient management .Cucurbits being vining in nature have responded very favourably to the training and support to the plants .This practice has to be further popularized .Similarly ,the package of practices have to be worked out for minor crops like gherkins ,sweet gourd ,kakoda etc. to make their cultivation more popular .

Integrated nutrient management in cucumber (*Cucumis sativus L.*) under protected cultivation

N. Ahmed, S. R. Singh, Anil Sharma, D. B. Singh,

Geetika Sheemar and Shabeena Yousuf

Div. of Vegetable Science and Floriculture, CITH, Srinagar

Abstract

Cucumber is an important vegetable praised for its refreshing nature and medicinal properties. It contains lariciresinol, pinoresinol, and secoisolariciresinol which reduce the risk of cardiovascular diseases and several cancers. Cucumber is very sensitive to low temperature and a soil temperature of at least 10 °C is needed at planting. Under hill conditions, its protected cultivation is getting momentum due to its low temperature sensitivity and suitability for vertical space production. Since, shortcomings of the sole use of chemical and organic sources of nutrition to the crops are now evident, the impact of integrated nutrient management (INM) on yield of cucumber variety SH-CH-1 under protected conditions was estimated using five treatments in four replications. The bio-fertilizers used were *Phosphate Solubilising Bacteria* (PSB) and *Azotobacter chrococum*. Although in first year of trial the recommended dose of chemical fertilizers gave highest yield, the second year recorded highest number of fruit/plant (22.16), average fruit weight (361 g) and fruit yield (1108.96 Kg/ha) with 50% RDF through chemical fertilizers along with 50% Vermicompost and bio-fertilizers. The results conclude that INM that includes half of the recommended dose of fertilizers combined with half of the recommended vermicompost complimented with PSB and *Azotobacter* under protected conditions gives highest yield in variety SH-CH-1. Although, the other treatments give lower yields than the combination of 50% RDF through chemical fertilizers along with 50% Vermicompost and bio-fertilizers but they are still higher than 100 per cent use of chemical fertilizers.

Effect of different spacing and training systems on yield of cucumber (*Cucumis sativus L.*) under protected cultivation

N. Ahmed, S. R. Singh, Anil Sharma, D. B. Singh,

Geetika Sheemar and Shabeena Yousuf

Div. of Vegetable Science and Floriculture, CITH, Srinagar

Abstract

Cucumber is relished as a salad item all over the world and also processed in pickled form. This crop is naturally sensitive to low temperatures. Therefore, to grow them under cold climatic conditions like those of North Himalayan agro-climatic conditions of India, the protected cultivation under polythene cover is a beneficial

option for the farmers. In order to standardize spacing and training systems for cucumber growing in protected structures, four varieties (Japanese Green Long, Pioneer Pickling, NSX-2 and Green Express) and two hybrids (SH-CH-1 and SH-CH-2) were evaluated with two spacing and three training system for three consecutive years. Considering all the three factors; genotypes, training systems and planting densities, the highest yield was recorded in SH-CH-1 (960.59 q/ha) trained to double stem at the spacing of 120 × 60 cm. Among varieties, Japanese Green Long showed highest yield (904.35 q/ha) in the same systems of spacing and training. The single stem training gave the highest yield while double stem was responsible for highest fruit number. Among different spacing studied, 120 × 60 cm demonstrated highest yield.

Role of GA₃ on morpho-physiological and yield parameters in bitter gourd (*Momordica charantia* L.)

Geeta Biradar, C. M. Nawalagatti and M. B. Chetti

*Department of Crop Physiology, College of Agriculture,
University of Agricultural Sciences, Dharwad*

Abstract

A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to study the effect of GA₃ on morpho-physiological and yield parameters in bitter gourd (*Momordica charantia* L.). The experiment consisted of two varieties (MHBI-15 and Chaman Plus) and three levels of GA₃ (20, 40 and 60 ppm) and water spray as control. The morpho-physiological parameters were taken in three different stages of plant growth (40, 60 and 75 DAS). The results of the investigation indicated significant differences between the treatments and varieties on vine length and number of leaves at all the stages. Among the treatments GA₃ @ 20 ppm had recorded significantly maximum vine length and number of leaves as compared to other treatments and control. The parameters of yield revealed that the maximum fruit yield was recorded significantly with the application of GA₃ (20 ppm) followed by GA₃ (40 ppm) and lowest yield was obtained in control. The increase in the yield was attributed to increase in number of female flowers per plant and number of fruits per plant. However, among the varieties, performance of Chaman plus was superior compared to MHBI-15 in all the parameters.

Response of Crop Geometry on the Performance of Parthenocarpic Varieties of Cucumber (*Cucumis sativus L.*) Under Controlled Polyhouse Condition

**Imran Khan, K. D. Ameta, R. A. Kaushik,
R. B. Dubey, S. Pareek and R. K. Jat**

*Department of Horticulture, Rajasthan College of Agriculture,
Maharana Pratap University of Agriculture and Technology,
Udaipur, Rajasthan-313001*

Abstract

An experiment was conducted to assess the effects of cultivars and spacing on yield and yield attributes of parthenocarpic cucumber grown under controlled polyhouse during summer. There were six cultivars viz. Nun-3134, Kian, Isatis, Infinity, Nun-3121 and Nun-3141 and three levels of spacing viz. 45 cm × 30 cm, 45 cm × 45 cm and 45 cm × 60 cm. The experiment was laid out in factorial completely randomized design with three replications. Observations were recorded on vegetative characteristics i.e. vine length, stem diameter, number of primary branches per vine and number of secondary branches per vine, number of first flowering node, internodal distance, days to anthesis of first flower and days to first harvest, yield and yield contributing characteristics i.e. number of fruits per vine, fruit weight, fruit length, fruit volume, fruit diameter, yield per vine and yield per square meter and quality characteristics i.e. specific gravity, TSS and moisture content. The results showed that all vegetative characters under study were significantly influenced by various cultivars and levels of spacing. Nun-3134 was found to be significantly superior in respect of yield and yield attributing traits having maximum values of 3.98 kg and 20.88 kg for yield per vine and per square meter, respectively. Interaction effects of cultivars and spacing were significant for most of vegetative characteristics except days to anthesis of first flower and days to first harvest. Among the treatment combinations, maximum yield per vine (4.30 kg) was recorded for Nun-3121 planted at a distance of 45 cm x 30 cm. However, maximum yield per square meter (26.66 kg) was recorded in Nun-3134 planted at a distance of 45 cm x 30 cm.

Evaluation of F₁ hybrids of cucumber (*Cucumis sativus*L.) under naturally ventilated polyhouse

**V. G Lajurkar, P. C. Mali, P. C. Haldavanekar, Y. R. Parulekar,
V. G Magar and N. R Phutankar**

*Department of Horticulture, College of Agriculture, Dr. Balasaheb Sawant Konkan
Krishi Vidyapeeth, Dapoli, District: Ratnagiri, Maharashtra -415 712*

Abstract

Cucumber (*Cucumis sativus* L.) is the most popular cucurbit grown in tropics and subtropics, which fetch premium price in markets all the year round. The F₁ hybrids of cucumber are becoming popular due to their high yielding ability especially under naturally ventilated polyhouse conditions. Hence, seventeen cucumber hybrids were studied for growth, yield and yield attributing characters under naturally ventilated polyhouse in Konkan agro climatic conditions. Data revealed that significant differences in the respect of various characters under study. It was evident that hybrid US-800 recorded the highest vine length (7.30 m), whereas hybrid Malini had maximum number of branches per vine (14). The lowest days to appearance of first male and female flower was recorded in hybrid Daynasty (35.40) and Swati (36.30) respectively. The first harvest noticed in hybrid Shighra (51.10 days) as well as highest harvesting span (35.90 days). Maximum number of harvestings was observed in hybrid Daynasty (14.40). In respects of physical parameters, maximum fruit length was noticed in hybrid Mahabharat (19.10 cm), whereas maximum fruit diameter in hybrid Malini (4.36 cm). The cucumber hybrid Malini was ranked first in respect of fruit weight (241.18 g), number of fruit per vine (23.70), fruit yield per vine (4.92 kg) and yield per hectare (716.46 qt). Thus, Hybrid Malini was found superior over rest of the cucumber of hybrids with regards to yield and yield attributing characters. Hence, hybrid Malini is suitable for cultivation in naturally ventilated polyhouse under Konkan agro climatic conditions.

Increasing productivity and water use efficiency of summer squash (*Cucurbita pepo L.*) using mulching and drip fertigation in Uttarakhand hills

Lalit Bhatt¹, V.P. Singh², S.K. Maurya¹, Dhirendra Singh¹, and J.P. Singh³

¹Dept. of Vegetable science, ²Dept. of Horticulture, ³Director Experiment Station
GB. Pant University of Agriculture and Technology, Pantnagar 263 145

Abstract

Summer squash (*Cucurbita pepo L.*) is a *Cucurbitaceous* vegetable of mild weather characterized by quick growth, early maturity and high yield. It performs well in cool and moist climatic condition and requires approximately 16-27 °C temperature for its normal growth and development. It has a great production potential under in Uttarakhand hill under mild climatic condition. Ease in cultivation, quick growth, higher yield and off season nature of crop lead to higher return per unit area under small and scattered land holdings, thus attracting number of vegetable growers toward its cultivation in rain fed situation. In spite of favourable climatic condition in Uttarakhand, cultivation of summer squash is not so easy. Low temperature during initial growth period followed by temperature fluctuations in latter part of the growth, moisture stress, less and erratic precipitation, depletion in available soil moisture due to increase in temperature and high wind velocity are some of the major constraints, which restrict the commercial cultivation of summer squash in mid – hill condition of Uttarakhand leading to low productivity. Considering the above facts a study was undertaken to investigate the effect of drip fertigation and mulching in improving the productivity and water use efficiency of summer squash under rain fed condition of Uttarakhand hills during spring summer of 2009 to 2011 under Ranichauri & Gwalmari Research station of G.B. Pant University of Agriculture and Technology and at farmer's field. The summer squash grown under drip irrigation and was mulched with black plastic mulch and with different locally available mulch materials i.e. Pine needles, Dry leaves, FYM, along with control in Randomized Block Design. The use of black plastic mulch in combination drip irrigation advanced the harvesting by 10 to 15 days. Besides extending the harvesting time it increased the total yield by 70 to 80 per cent over farmers' practice at various locations. Summer squash cultivation using drip system and black plastic mulch not only reduced the water requirement by 40 to 60 per cent but also two fold to three fold water use efficiency (WUE). The economic analysis of the study revealed that the use of black plastic mulch in combination with drip fertigation in summer squash gave highest benefit cost ratio of 3.75 compared to 1.78 in case of farmer's practice.

Integrated Nutrient Management in Cucumber Grown Under Open Condition for Bastar Plateau of Chhattisgarh

G P. Nag¹*, Deo Shankar², M. S. Paikra² and D. P. Singh²

¹*College of Horticulture, Jagdalpur-494 005, ²SG College of Agriculture & Research Station, Jagdalpur-494 005*

Abstract

An experiment was conducted at SG, Collage of Agriculture & Research Station, Jagdalpur (C.G.), during summer 2013 to study the effect of integrated nutrient management on growth, yield and quality attributes of Cucumber (Cv. Pusa Sanyog) grown under open condition. The experiment was laid out in RBD with ten treatments and four replications. The results revealed that application of 100% RDF (60:60:80 kg NPK ha⁻¹) + 100 % Vermicompost (2.0 t ha⁻¹) + Azotobacter (AZT) 4.0 kg ha⁻¹ + Phosphobacteria (PSB) 5.0 kg ha⁻¹ + Trichoderma 5 kg ha⁻¹ given highest fruit yield (37.87 t ha⁻¹) it was significantly superior than all over the treatments and followed by treatment 75% RDF + 50 % FYM + 50% Vermicompost (1.0 t ha⁻¹) + Azotobacter (AZT) 4 kg ha⁻¹ + Phosphobacteria(PSB) 5kg ha⁻¹ + Trichoderma 5 kg ha⁻¹ given fruit yield (36.20 t ha⁻¹), Treatment 100% recommended dose fertiliser (60:60:80 kg NPK ha⁻¹) + 100% FYM 25 t ha⁻¹ given fruit yield (35.57 t ha⁻¹), treatment 50% RDF + 50 % FYM + Azotobacter (AZT) 4 kg ha⁻¹ + Phosphobacteria(PSB) 5kg ha⁻¹ + Trichoderma 5 kg ha⁻¹ given fruit yield (35.32 t ha⁻¹) and treatment 75% RDF + 75% Vermicompost (1.5t ha⁻¹) + Azotobacter (AZT) 4 kg ha⁻¹ + Phosphobacteria(PSB) 5kg ha⁻¹ + Trichoderma 5 kg ha⁻¹given fruit yield (35.17 t ha⁻¹). Under the growth parameters maximum plant height (2.47 m), number of leaves per plant (90.75 nos.) and number of branches per plant (6.0 nos.) was recorded in treatment T₄ - 100% RDF + 100 % Vermicompost (2t ha⁻¹) + Azotobacter (AZT) 4 kg ha⁻¹ + Phosphobacteria(PSB) 5kg ha⁻¹ + Trichoderma 5 kg ha⁻¹. It may be conclude that the treatment T₄ 100% RDF + 100 % Vermicompost (2t ha⁻¹) + Azotobacter (AZT) 4 kg ha⁻¹ + Phosphobacteria(PSB) 5kg ha⁻¹ + Trichoderma 5 kg ha⁻¹ may be recommended to farmers for commercial production of Cucumber under open condition for Bastar Plateau of Chhattisgarh.

Effect of mulches and level of irrigation on crop yield for bottle gourd – A Review

Padmakshi Thakur, Sasmita Priyadarsini Dash

Department of Horticulture, IGKV, Raipur – 492012

Abstract

Mulching with drip irrigation system is an effective method of manipulating crop growing environment to increase crop yield. Mulching helps in minimizing disease incidence and harmful microbial activities. It has various advantages viz., reduced evaporation, weed control, reduced soil compaction and root pruning, reduction in fertilizer losses, insect control and also allow other components, such as drip irrigation to achieve maximum efficiency. A field experiments were conducted to assess the impacts of different type of mulches with different level of irrigation through drip irrigation system on performance of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] in PFDC, IGKV, Raipur during the year 2011-12. The crop yield was found maximum under black plastic mulch with 80% of CWR (Crop Water Requirement) through drip irrigation system, followed by paddy straw mulch and without mulch with drip system in a split plot design. The benefit cost ratio was found maximum (2.14) fewer than 80% of CWR through drip irrigation system with black plastic mulch. These improvements of crop growing environment resulted in increased bottle gourd growth and fruit yield.

Problems and Prospects for Off-season Cultivation of Watermelon in River Beds under Terai zone of West Bengal—a SWOT Analysis

Ranjit Chatterjee and P. K. Pal

Uttar BangaKrishiViswavidyalaya, Pundibari, Cooch Behar-736165(W.B.)

Abstract

Watermelon is emerging as an important cash crop in the river bed of *Toorsa* and *Mansai* river of Coochbehar during the winter months due to increasing demand of off-season watermelons in big cities like Kolkata, Guwahati, Silchar and neighbouring Bangladesh and Bhutan. The micro climate of riverbed favours watermelon cultivation during winter months. The landless communities utilize the

river bank to earn their livelihood through off-season cultivation of watermelon. The seeds are sown in November with the onset of winter and fruits are harvested from March onwards till hot summer of May. However, there is a huge gap between potential yield and actual yield which make the system less remunerative. In spite of the favourable climate, vast unutilized land and market opportunities, the poor outcome from the system force these vulnerable communities to migrate to other places to earn their livelihood. In this backdrop, the present study was formulated to gain insight on the problems and prospects of this potential production system by conducting strength, weakness, opportunity and threat (SWOT) analysis on the bank of river *Toorsa* and *Mansai* of Coochbehar district during 2013-14. Information was collected through participatory approach and personal interview of selected water melon farmers. In the paper, the detailed investigation of SWOT analysis was highlighted. The outcome will result in better understanding of the sector and the intervention will make the system more productive and economically viable.

Influence of Growth Regulators on Growth and Yield of Gherkins (*Cucumis anguria* Linn.) CV. Ajax

S.P.Satose, R.N.Nawale,P.C.Haldavanekar, Y.R.Parulekar and P.M.Haldankar
Department of Horticulture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli (MS)

Abstract

Gherkin (*Cucumis anguria* Linn.) belongs to family Cucurbitaceae is one of the important cucurbits cultivated exclusively for export. It is also called as 'West Indian Gherkin' or 'Burr cucumber' or 'Gooseberry gourd' or 'Pickling cucumber'. It is mainly used for pickling and also as mixed green salad. The ultimate yield is dependent on the number of female flowers produced on the plant. The role of plant growth regulators in altering sex expression in cucurbitaceous crops is well known. The climatic conditions of Konkan region are ideal for cultivation of gherkins during rabi cum summer season. However, the information on use of PGRs on sex modification in gherkins under Konkan condition is lacking. Hence, present investigation on "Influence of growth regulators on growth and yield of gherkins CV. AJAX was conducted under Konkan agro climatic condition of Maharashtra. The treatments NAA (50,100 and 150ppm), GA3 (15 and 30ppm), Ethrel (100 and 200ppm), TR1A

(2, 4 and 6ppm), PBZ (50,100 and 150ppm) and control (water spray) were applied in the form foliar sprays each at two and four true leaf stages. The results showed that all the treatments showed significant variations for growth and yield parameters of gherkin Cv. Ajax. Among all the treatments studied significantly the highest fruit yield of gherkin Cv. Ajax was observed at 100 ppm ethrel over all the growth regulator treatments under study. Foliar sprays of GA3, NAA and triacontanol promoted vegetative growth, whereas PBZ retarded the same. The findings showed that ethrel 100ppm and triacontanol 4ppm had shown better results for yield maximization in gherkin cv. Ajax under Konkan agro-climatic conditions of Maharashtra.

Effect of fertigation and shade on quality traits of cucumber (*Cucumis sativus L.*)

T. Sumathi, V. Ponnuswami, V. Pramela and R. Akila

*Department of vegetable crops, Horticultural College and Research Institute
TamilNadu Agricultural University, Coimbatore*

Abstract

Field experiments were conducted at the Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to elucidate the effect of shade and fertigation on quality of cucumber hybrid 'NS 404'. Based on the observations recorded on the various quality parameters, it was revealed that the fertigation treatments with 100 per cent water soluble fertilizers applied in combination with calcium chloride spray registered the maximum values under shade net condition and improved most of the quality parameters. The fruit quality traits viz., firmness, TSS, ascorbic acid, titrable acidity, shelf life and moisture content were improved with the application of 100 per cent water soluble fertilizer plus calcium chloride combinations. The results also revealed that the ca content of the cucumber fruits increased dramatically with the application of pre-harvest foliar sprays of CaCl_2 (1.0 per cent). Microtomy study was undertaken to determine the role of calcium in cell wall thickening and turgidity maintenance in the fruits. The data have vividly revealed that calcium accumulation was indicated in the microtomy sectioning by the appearance of blackening around the cell.

Effect of cucurbitaceous rootstocks on survival, growth and yield of bitter gourd (*Momordica charantia* L.)

¹N. A. Tamil Selvi, ²L. Pugalendhi and ³T. Saraswathi

^{1,3}Horticulture College and Research Institute, Coimbatore- 641 003,

²Tapioca and Castor Research Station, Yethapur, Salem-636 119

Abstract

An investigation was carried out at the Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agriculture University, Coimbatore during 2011-2013 with Cucurbitaceous rootstocks and two bitter gourd scions (Palee F₁ and CO1) to determine the effect of side grafting on survival, growth and yield of bitter gourd grafts. The observations on survival percentage revealed that Palee F₁ grafted onto pumpkin (*Cucurbita moschata*) rootstock recorded the highest success percentage (89.05, 78.90 and 71.70), followed by sponge gourd rootstock (85.35, 74.35 and 68.26 per cent) at 15,30 and 45 days after grafting respectively. The lowest success percentage was observed, when bitter gourd grafted on to mithipakal (*Momordica charantia* var. *muricata*) followed by fig leaf gourd (*Cucurbita ficifolia*) rootstock respectively. The grafted plants are planted in the field along with non grafted plants (control). The results revealed that Palee F₁ grafted onto pumpkin rootstock was found to be the best as it expressed good performance for vine length (856.66 cm), number of branches (13.16), fruit number per vine (27.88), fruit weight (183.66 g), fruit yield per vine (3.62 kg) as compared to other graft combinations as well as non grafted plants. Furthermore, grafting had no significant effect on fruit quality.

Effect of varying levels of nitrogen, phosphorus and potassium on Growth and Yield of Bottle gourd under Southern dry region of Karnataka

P. Umamaheswarappa, K. Krishnappa and M. Pitchaimuthu

Division of Horticulture, University of Agricultural Sciences, Bangalore-560 065

Abstract

Bottle gourd [*Lagenaria siceraria* (Mol). Standl] is popular Cucurbitaceous vegetable crop is grown in around the year in all the seasons in all parts of India. It is becoming popular in most of the states to raise two or three crops in a year. It is mainly grown for its fruits both in tropics and subtropics of the world. It is one of the

early maturing vine vegetable crop. It is known that primary nutrients are essential for increasing crop growth and yields. The nutrients requirement of crop depends on cultivar, soil fertility, soil conditions and also agro climatic conditions. However, there is little information available on nutrient requirement of this crop. Therefore, this study was undertaken to study the effect of varying levels of nitrogen, phosphorus and potassium on growth and yield of Bottle gourd Cv. Arka Bahar in southern dry region of Karnataka at Horticultural Research Station, Gandhi KrishiVigyan Kendra, Bangalore in plot size of 5x5 m at a spacing of 3.0 x 0.9 m during *kharif* season and the experiment laid out in a factorial randomised complete block design with three replications and consisted of three levels each of nitrogen(0, 60 and 120 kg/ha), phosphorus(0, 50 and 100 kg/ha) and potassium(0, 30 and 60 kg/ha). Observations were recorded for vine length(cm), Number of leaves, Number of branches per vine (cm), vine girth at collar region(cm), Number of male flowers per vine, Number of female flowers per vine, length of fruit(cm), girth of fruit(cm), weight of fruit(g) and fruit yield(t/ha). Different levels of NPK differed significantly for the characters studies. Among the different NPK levels tested the application of 120:50:60 kg NPK/ ha recorded the highest fruit yield of 33.47(t/ha) and the lowest yield of 26.69 (t/ha) was recorded in the control. Among the different levels of NPK tested 120:50:60 kg NPK/ha had high fruit yield.

Uptake of nitrogen, phosphorus and potassium by plant and leaf chlorophyll content of Bottle gourd Cv. Arka Bahar under Southern dry region of Karnataka

P. Umamaheswarappa, K. Krishnappa and M.Pitchaimuthu

Division of Horticulture, University of Agricultural Sciences, Bangalore-560 065

Abstract

Bottle gourd [*Lagenaria siceraria* (Mol). Standl] is one of the most important and popular *Cucurbitaceous* vegetable belonging to family Cucurbitaceae. It is grown extensively in around the year in all the seasons in all parts of India. It is becoming popular in most of the states to raise two or three crops in a year. It is mainly grown for its fruits both in tropics and subtropics of the world. It is one of the early maturing vine vegetable crop. It is known that primary nutrients are essential for increasing crop growth and nutrients uptake by plant. The nutrients requirement of crop depends on cultivar, soil fertility, soil conditions and also agro climatic conditions. However, there is little information available on nutrient requirement of this crop. Therefore, this study was undertaken to study the effect of varying levels of nitrogen, phosphorus and potassium on uptake of NPK by plant and leaf chlorophyll content of Bottle gourd Cv. Arka Bahar in southern dry region of Karnataka at Horticultural Research Station,

Gandhi Krishi Vigyan Kendra, Bangalore in plot size of 5x5 m at a spacing of 3.0 x 0.9 m during *kharif* season and the experiment laid out in a factorial randomised complete block design with three replications and consisted of three levels each of nitrogen(0, 60 and 120 kg/ha), phosphorus(0, 50 and 100 kg/ha) and potassium(0, 30 and 60 kg/ha). Observations were recorded for uptake of N by plant, uptake of P by plant, uptake of K by plant, Chlorophyll *a* content in leaf, Chlorophyll *b* content in leaf, Total chlorophyll content in leaf. Different levels of NPK differed significantly for the characters studies. Among the different NPK levels tested the application of 120:50:60 kg NPK/ha recorded the highest uptake of NPK by plant. Among the different levels of NPK tested 120:50:60 kg NPK/ha had high total chlorophyll content.

Effect of varying levels of nitrogen, phosphorus and potassium on Flowering, Fruit set and Sex Ratio of Bottle gourd under Southern dry region of Karnataka

P. Umamaheswarappa, K. Krishnappa and M. Pitchaimuthu

Division of Horticulture, University of Agricultural Sciences, Bangalore-560 065

Abstract

Bottle gourd [*Lagenaria siceraria*(Mol).Standl] is one of the most important and popular Cucurbitaceous vegetable belonging to family *Cucurbitaceae*. It is grown extensively in around the year in all the seasons in all parts of India. It is mainly grown for its fruits both in tropics and subtropics of the world. It is one of the early maturing vine vegetable crop. Flowering and fruit set are governed by the genetic makeup and environmental factors in which they grow. Being a crop of having diverse sex forms, drift in sex ratio becomes a major limiting factor for the production affecting the yield. It is known that primary nutrients are essential for increasing crop yields. Nutrition is the limiting factor of plant growth and production. However, there is little information available on nutrient requirement of this crop. Therefore, this study was undertaken to study the effect of nitrogen, phosphorus and potassium on flowering, fruit set and sex ratio of Bottle gourd Cv. Arka Bahar in southern dry region of Karnataka at Horticultural Research Station, Gandhi KrishiVigyan Kendra, Bangalore in plot size of 5x5 m at a spacing of 3.0 x 0.9 m during *kharif* season and the experiment laid out in a factorial randomised complete block design with three replications and consisted of three levels each of nitrogen(0,60 and 120 kg/ha), phosphorus(0,50 and 100 kg/ha) and potassium(0,30 and 60 kg/ha). Observations were recorded for Days to appearance of first male flower, Days to appearance of first female flower, Number of days required for first fruit set, Fruit set per cent and Sex ratio. Different levels of NPK differed significantly for the characters studies. Among the different NPK levels tested the application of 120:50:30 kg NPK/ha recorded the highest per cent of fruit set and Sex ratio.

Effect of varying levels of nitrogen, phosphorus and potassium on Flowering, Fruit set and Sex Ratio of cucumber (*Cucumis sativus*. L) under Southern dry region of Karnataka

P. Umamaheswarappa, K. Krishnappa and M. Pitchaimuthu

Division of Horticulture, University of Agricultural Sciences, Bangalore-560 065

Abstract

Cucumber (*Cucumis sativus*. L) is an important vegetable crop belongs to family Cucurbitaceae. It is grown in around the year in all the seasons in all parts of India. It is mainly grown for its fruits both in tropics and subtropics of the world. It is one of the early maturing vine vegetable crop. Flowering and fruit set are governed by the genetic makeup and environmental factors in which they grow. Being a crop of having diverse sex forms, drift in sex ratio becomes a major limiting factor for the production affecting the yield. It is known that primary nutrients are essential for increasing crop yields. Nutrition is the limiting factor of plant growth and production. However, there is little information available on nutrient requirement of this crop. Therefore, this study was undertaken to study the effect of nitrogen, phosphorus and potassium on flowering, fruit set and sex ratio of cucumber Cv. Poinsette in southern dry region of Karnataka at Horticultural Research Station, Gandhi Krishi Vigyan Kendra, Bangalore in plot size of 5x5 m at a spacing of 2.5 x 0.8 m during *kharif* season and the experiment laid out in a factorial randomised complete block design with three replications and consisted of three levels each of nitrogen(0,60 and 120 kg/ha), phosphorus(0,50 and 100 kg/ha) and potassium(0,40 and 80 kg/ha). Observations were recorded for Days to appearance of first male flower, Days to appearance of first female flower, Number of days required for first fruit set, Fruit set per cent and Sex ratio. Different levels of NPK differed significantly for the characters studies. Among the different NPK levels tested the application of 120:50:40 kg NPK/ha recorded the highest per cent of fruit set(71.96) and Sex ratio of 5.60 and the sex ratio of 4.62 was recorded in the control. Among the different levels of NPK tested 120:50:40 kg NPK/ha had high fruit set and sex ratio.

Impact of Drip irrigation technology in Muskmelon cultivation for rural prosperity

P. Umamaheswarappa and A.H. Kumar Naik

Zonal Horticultural Research Station, Babbur Farm, Hiriyur – 577 598

Abstract

Although water is a renewable resource, its availability in appropriate quality & quantity is under severe stress due to increasing demand from various sectors. Agriculture is the largest user of water which consume more than 80% of the country's exploitable water resources. The conventional method of irrigation for particularly Horticulture & vegetable crops highly inefficient has led not only to wastage of water but also to several ecological problems. It has been recognized that use of surface as well as ground water resources. Drip irrigation is the latest economical cheapest method of water management in Muskmelon. It is the most suited for vegetable crops, like Musk melon and find applicability in area where ground water is scarce & helps in optimization of limited water resources. Through Drip irrigation system advantages are in terms of saving of water (40-60%) of that required for flow irrigation, effective use of fertilizer, less labour energy cost and also enhance the quality of produce. Keeping this, in view, most of the farmers in the villages were having an area of 1-2 Drip irrigation system provided with help of Department of Horticulture under micro irrigation project. On the basis of 2 years results in the farmer field revealed that production increased yield upto 30% in Muskmelon as compared to traditional irrigation system and also water saving through Drip irrigation is 40% in Musk melon were observed. By using Drip irrigation system nutrient use efficiency can also be increased up to 60-70% as compared to 35-45% in conventional irrigation system. Seeing the significant impact of Drip irrigation technology. Other Musk melon growers have been adopted Drip irrigation in Chitradurga district.

Growth and Yield of cucumber (*Cucumis sativus*. L) as influenced by varying levels of nitrogen, phosphorus and potassium under Southern dry region of Karnataka

P. Umamaheswarappa, K. Krishnappa and M.Pitchaimuthu

Division of Horticulture, University of Agricultural Sciences, Bangalore-560 065

Abstract

Cucumber (*Cucumis sativus*. L) being is one of the most important commercial Cucurbitaceous vegetable crop is grown in around the year in all the seasons in India. It is becoming popular in most of the states to raise two or three crops in a year. It is mainly grown for its fruits both in tropics and subtropics of the world. It is one of

the quickest maturing vine vegetable crop. It is known that primary nutrients are essential for increasing crop yields. The nutrients requirement of crop depends on cultivar, soil fertility, soil conditions and also agro climatic conditions. However, there is little information available on nutrient requirement of this crop. Therefore, this study was undertaken to study the effect of varying levels of nitrogen, phosphorus and potassium on growth and yield of cucumber Cv. Poinsette in southern dry region of Karnataka at Horticultural Research Station, Gandhi Krishi Vigyan Kendra, Bangalore in plot size of 5x5 m at a spacing of 2.5 x 0.8 m during *kharif* season and the experiment laid out in a factorial randomised complete block design with three replications and consisted of three levels each of nitrogen(0,60 and 120 kg/ha), phosphorus(0,50 and 100 kg/ha) and potassium(0,40 and 80 kg/ha). Observations were recorded for vine length(cm), Number of leaves, Number of branches per vine (cm), vine girth at collar region(cm), length of fruit(cm), girth of fruit(cm), weight of fruit(g) and fruit yield(t/ha). Different levels of NPK differed significantly for the characters studies. Among the different NPK levels tested the application of 120:50:40 kg NPK/ha recorded the highest fruit yield of 13.17(t/ha) and the lowest yield of 8.56 t/ha was recorded in the control. Among the different levels of NPK tested 120:50:40 kg NPK/ha had high fruit yield.

Growing cucurbitaceous crops under low cost poly house in North east India

S. D. Warade, A. K. Pandey, R. K. Dubey, V. Singh, V. B. S. Chavan
College of Horticulture and Forestry, Pasighat 791 102

Abstract

The North Eastern Hill (NEH) region comprising of eight states namely Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland, Tripura and Sikkim. In the whole of NEH region, about 65% area is in the hills and only 35 % area is under plains. The climate is warm tropical to temperate. The NEH region comprises of high rainfall to rain shadow area receiving very less rainfall. There are vegetables, which cannot be grown due to high rainfall from April to October. From October to February (winter season), the temperature is low. During this period, vegetables can be grown successfully by protecting them from heavy rainfall and low temperature. Production of vegetables under protected conditions involves protection of production stages of vegetables mainly from adverse environmental conditions such as temperature, high rainfall, hail storms, scorching sun etc. The greenhouses are constructed essentially as rain shelters to permit off-season vegetable production. Efforts have been made at College of Horticulture and Forestry, CAU, Pasighat (Arunachal Pradesh) to grow the vegetable crops like cucumber, bottle gourd, bitter gourd during the off season. Protected conditions for vegetable production was created locally by using structure of locally available bamboos' and covered with UV

stabilized plastic film. The performance of the crop was good. There was an appreciable vegetative growth of the plants. The yield per sq m was for cucumber 2.1 kg, bottle gourd 3.5 kg, bitter gourd 2.8 kg. The results indicated that protected cultivation can be adopted practically to boost the yield and availability of vegetable crops in most part of the year. The adoption of the technology will be the boon for the farmers in boosting the vegetable production for supply of vegetables to the people of the region ensuring health security.

Evaluation of Parthenocarpic Vs Monoecious cultivars of Cucumber (*Cucumis sativusL.*) in Polyhouse under Tarai Condition of Uttarakhand

Monisha Rawat, S. K. Maurya, Lalit Bhatt, J. P. Singh and P. K. Singh

GB. Pant University of Agriculture and Technology Pantnagar-263 145, Uttarakhand

Abstract

Cucumber (*Cucumis sativus L.*, $2n=2x=14$), an economically important member of the gourd family, Cucurbitaceae. A number of varieties/hybrids have been recently developed in the country in this crop but little effort has been made so far to evaluate them for their suitability of growing under green house conditions. In this context, present study was planned with the objectives to evaluate promising parthenocarpic and monoecious cultivars of cucumber in a naturally ventilated polyhouse for flowering, maturity, plant architecture, yield and yield attributes during the rabi as well as summer season. The experiment involving 10 genotypes includes five parthenocarpic varieties namely Hilton, Kian, Isatis, PPC-2 and PPC-3 and five monoecious F_1 hybrids namely Malini, Kamini, Sheetal, Alamgir CT-180 and NS-404, collected from different sources. The experiment was conducted during the rabi season of 2012-13 and summer season of 2013 at the Precision Farming Development Centre (PFDC) of the G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand. The experiment was laid out in a Randomized Block Design (RBD) using four replications. Each genotype had one row, 3 m long with a plant spacing of 60×60 cm. Appreciable performances were recorded for twelve horticultural traits. The ten genotypes had a wide range of variation for most of the characters under investigation. For fruit yield per hectare in rabi season, the Parthenocarpic hybrids Kian (200.15 q), Isatis (188.78 q), and Hilton (144.30 q) were the top performers and superior over the check variety PPC-3 (122.22 q), however, Sheetal was the least yielder genotype with 82.13 q/ha fruit yield and in summer season, the genotypes Malini (590.76 q), Hilton (572.80 q), and NS-404 (523.77 q) were the top performers and superior than the check variety PPC-3 (449.02 q). However, Sheetal was the least yielder genotype with 318.19 q/ha fruit yield. The high fruit yield recorded in the genotypes has been directly attributed to increased number of fruits per plant. Therefore, it is recommended that such genotypes can be grown for commercial cultivation in the farmer's field under protected cultivation under Tarai condition of Uttarakhand.

Growth and yield of cucumber as influenced by different sowing dates under polyhouse as off season crop

Ms. Sapna Boruah and Dr. Deepa Borbora Phookan
Horticulture Department, Assam Agricultural University, Assam

Abstract

Cucumber experiments under polyhouse were conducted during 2012-13 and 2013-14 in the Experimental Farm of the Horticulture department of Assam Agricultural University under Naturally Ventilated polyhouse. The study was carried out in Randomized Block Design with five replications. Seeds of cucumber cultivar Alisha F-1 was sown in four sowing dates at monthly intervals from middle of October to middle of January. Umbrella system of pruning was adopted. Seeds are sown at a distance of 60 cm between rows and 30 cm between plants. Different growth and yield attributing parameters were determined. Among the four different dated of planting the highest number of 19.43 fruits per plant was recorded in January sown crops which was significantly highest than the other dates of sowing. The highest yield of 4.28 kg per plant was recorded from two years pooled data in January sowing crop. Though there was no significant difference in the female to male ratio. However two years pooled data showed that the highest fruit setting percentage of 43.38 was recorded in January sowing crops. As an off season crop cucumber can be grown in all the four sowing dated however, January sowing date gives the best performance.

Potential of minor cucurbits for enhanced income for livelihood support for small and marginal farmers of Odisha

L.K. Bharathi, A.B. Mishra and P. Srinivas
Central Horticultural Experiment Station (IIHR)
Aiginia, Bhubaneswar -751019, Odisha

Abstract

Underutilized cucurbits have been promoted for commercial cultivation in different parts Odisha. The improved varieties of cucurbitaceous crops like teasel gourd, spine gourd, pointed gourd and ivy gourd developed at CHES, Bhubaneswar were provided to the beneficiary farmers to study their potential adoption, commercial viability and sustainability. More than 100 farmers are provided with quality planting material and technical knowhow on cultivation aspects in three districts of Odisha. Village wise training programmes have been conducted for technology dissemination for the scientific production and protection of under-

utilized crops. Further, skill based strengthening of existing SHGs for commercial production of planting material was also provided. The results indicated that these vegetable crops being very popular in the eastern region of India for their culinary value, there was almost no hindrance in adoption of the technology of scientific cultivation of cucurbits. The maximum survivability was observed in the teasel gourd. However, being the new crop in the area and due to the requirement of artificial pollination, some of the farmers failed to get fruits in teasel gourd crop. Nevertheless the farmers gained the pollination skills in the subsequent on campus and off campus trainings. It is observed that being the vegetatively propagated long duration crop there was more potential of self-sustainability of the technology. The commercial viability of these crops was established. Households with 250m² area under of cultivable irrigated land, with investment cost of Rs. 1000.00 for manures and other inputs for could easily earn up to Rs. 5000 per crop. Some self help groups have been able to harvest the tubers from previous seasons and produce seedlings on commercial basis while promoting the crop in the nearby areas. It is concluded that the underutilised cucurbits hold immense potential for expansion in Odisha especially in far reaching rural and tribal areas, owing to their higher per unit production with lesser requirement of inputs.

SESSION IV

**GENETIC RESOURCES IN CUCURBITS: DIVERSITY,
CONSERVATION AND UTILIZATION**

Production of quality planting material in vegetatively propagated cucurbits: Key issues and Way forward

A.K. Singh, Bikash Das and P. Bhavana

ICAR-RCER Research Centre, Plandu, Ranchi-10, Jharkhand, India

Abstract

Dioecious cucurbits like pointed gourd, ivy gourd, spine gourd are vegetatively propagated because of poor seed germination and inability to determinate the sex of plants before flowering. Vine cuttings, root suckers and tuberous roots are usually used for their propagation. Pointed gourd commonly known as parwal is a newly introduced crop in Jharkhand and is highly potential crop for the farmers due to demand within the state as well as from neighboring states. Research on this crop was initiated in ICAR RCER Research Centre, Ranchi to provide improved varieties having desirable qualities for table and sweet preparations. Clonal selection resulted in the release of three varieties viz. Swarna Rekha (green, striped, 15-20t/ha)(CVRC), Swarna Alaukik (Light green, 15-20t/ha)(CVRC) and Swarna Suruchi (light green, 25-30t/ha)(CVRC) suitable for cultivation in Jharkhand, Bihar, Orissa, West Bengal and Eastern U.P. They are high yielding and highly appreciated by the farming community. Increase in demand for quality planting material emphasized research on mass multiplication programme of these varieties to cater to the needs of the farmers of eastern plateau and hill region. This resulted in standardization of the method of double node cutting. Experiment conducted at the Centre showed that this method is highly efficient than the traditional method of coiled vine with 7-8 nodes, which requires more planting material and less success rate. Roots are used by the farmers of Orissa but multiplication rate is very low.

In this method, double node cuttings are planted with one node inside the soil and the other node outside during 15th Aug- 15th Sep. Care should be taken to collect the explants from runner vines than the climbing vines as runner vines result in 100% success. They can be planted on a soil bed or in polyethene bags. Polybag is filled with soil containing organic manure (40-50%), SSP (2kg/100kg soil) and Lime (5kg/ha). IBA 500ppm is used as rooting enhancer. Leaves emerge within 15 days and cuttings are ready for planting within one month. This method has shown a high success rate. This technique is simple, inexpensive and can be easily followed by the farmers. Also large number of planting material can be obtained with less explants. Nearly 25,000 cuttings are produced every year by the Centre.

Research was also initiated on in vitro multiplication of pointed gourd. Inoculation of explants in MS media containing BA 1.0 ppm + IAA 0.2ppm for emergence of vigorous shoots and reculturing of emerged shoots in MS media containing IAA 0.2 ppm + IBA 1.5ppm was most effective treatment for invitro multiplication of pointed gourd.

Scope of micro-propagation for faster spread of planting material for commercial cultivation

Dr. Subhash N.

Professor & Head, Plant Tissue Culture, Dept. of Agricultural Biotechnology, Anand Agricultural University, Anand 300 110, Gujarat

Abstract

Cucurbits have the greatest potential to boost overall production and enhance nutritional security as many of the crops of this family still remain underutilized mainly due to unavailability of superior planting material. Most of the cucurbits are being propagated through seed, vine cutting and underground root/stem. Due to highly cross pollinated in nature and dioeciousness in some of the cucurbits, maintenance of genetic uniformity as well as sex ratio is one of the major drawbacks with seed propagation. Propagation through vine cuttings and root suckers is labour intensive and also requires bulk quantity of vines/roots, which restricts their multiplication at commercial level. In order to overcome these problems, tissue culture techniques play very important role in production of large number of disease free plants from desirable/selected superior genotypes/clones. *In vitro* propagation / micropropagation using shoot tip culture in pointed gourd, spine gourd, cucumber and watermelon has been successfully achieved to multiply selected clones in short period. Tissue culture raised plants of dioecious cucurbits like pointed gourd and spine gourd showed very good field establishment, cent per cent uniformity in sex expression along with higher production of fruits for longer duration and years as compared to conventionally raised plants (through cuttings). Meristem culture followed by Micropropagation holds inevitable in cases wherein *Cucumis virus - I* and *III* is common in crops like bitter gourd, bottle gourd, cucumber, watermelon and other cucurbits hosts.

Production of planting material from stem cuttings of some dioecious Cucurbits

T. Maharana, K.C. Sahoo & Kaberi Maharana

Orissa University of Agriculture & Technology, Bhubaneswar-751003

Abstract

Among the four dioecious Cucurbits namely, *Momordica dioica*, *Momordica subangulata sub sp. renigera*, *Melothria heterophylla* and *Trichosanthes dioica*, all can produce roots from stem cuttings. But rooting is poor in *Melothria heterophylla*. Within seventy days, *M. dioica* can produce nearly twenty gram weight tuberous root, whereas fifteen gram tuberous root can be produced in *M. subangulata subsp. renigera*. The storage loss of tuberous root is less in *M. dioica* and therefore production of planting material from stem cuttings of *M. dioica* can be easily done. *M. subangulata subsp. renigera* as such can be propagated through stem cuttings without going for tuber production. However, tuber production can be made. Details study should be made for *Melothria heterophylla*. Terminal one node cuttings with IBA 25 ppm to 100 ppm treatment can give rise better rooting in *Trichosanthes dioica*. Within seventy days rooted cuttings of *T. dioica* can produce up to sixteen grams of tuberous root. The present study can be used as a tool for propagation of high yielding elite dioecious cucurbits. This will also help for maintenance of desired sex ratio in the cultivators field.

Effect of seed invigouration on seed quality in fresh and aged cucumber seeds

Pratima Pandey¹ and K. Bhanuprakash²

¹Nepal Agricultural Research Council, Nepal, ²Indian Institute of Horticulture Research (IIHR), Bangalore

Abstract

Cucumber (*Cucumis sativus L.*) is one of the most important vegetables grown in the world and the ever growing demand to this vegetable throughout the year exert challenge for continuous production even during off season. However, its production and productivity is largely influenced by quality of seeds, type of soil, climate exposed, agronomic practices followed etc. Cucumber seeds loose viability during storage and more quickly under high humid and high temperature conditions. Seed invigouration is one of the techniques commonly followed to obtain better crop stand particularly if the initial seed quality is poor and climate or soil conditions are not favorable. In the present investigation, in order to find out a suitable chemical and its concentration for optimum seed priming, cucumber seeds (both fresh and aged) were soaked in various chemicals (KH_2PO_4 0.1M, KH_2PO_4 0.001M, K_2HPO_4 0.1M, K_2HPO_4 0.001M, Water, KNO_3 0.5%, KNO_3 1%, GA_3 500PPM, GA_3 1000PPM, CaCl_2 0.1M, CaCl_2 0.001M, Oxalic Acid 0.1M, Oxalic Acid

0.001M, Salicylic Acid 0.1%, Salicylic Acid 0.5%) at two different concentration for 48 hours at ambient condition. Fresh seed lot (90%) was subjected to accelerated ageing (AA) as per ISTA ($45^{\circ}\text{C} + 100\% \text{ RH}$) for 5 days to obtain less viable (aged) seed lot (50%). Besides, reduction in the germination (40 %), AA also reduced seedling vigour index by 46.3% and increased days to T_{50} by three days. Further 12.5% higher abnormal seedlings were noticed in AA seeds compared to unaged. However, seed priming of less viable (aged) seeds with KH_2PO_4 0.1M, salicylic acid 0.5%, KH_2PO_4 0.001M, GA_3 500 ppm restored all the quality parameters that contribute vigour. Seed priming with KH_2PO_4 0.1M increased germination, vigour index and decreased days to T_{50} , abnormal seedlings by 12.5%, 50.9% and 1.0, 15%, respectively. Similar significant results were also noticed due to seed priming with salicylic acid 0.5%, KH_2PO_4 0.001M and GA_3 500 ppm. Marked increase even in fresh seeds vigour due to seed priming was also noticed in the present investigation. Thus, it is concluded that priming of cucumber seeds with KH_2PO_4 0.1M for 48 hours at ambient condition improves seed quality parameters that contribute to vigour for better crop stand establishment.

Tissue culture propagation of spine gourd (*Momordica dioica Roxb.*) An underutilized vegetable with high nutritional and medicinal value

B. Rekha

Department of Horticulture, University of Agricultural Sciences, Dharwad

Abstract

Momordica dioica Roxb. belongs to the family Cucurbitaceae commonly called as Spine gourd. Spine gourd is consumed by tribal groups living around the natural forest areas. Spine gourd is a perennial dioecious climber, fruits are having high nutritional value, used against diarrhea, diabetes, asthma etc. seeds have dormancy due to hard seed coat and this can be broken through tissue culture method. Tissue culture studies in spine gourd was conducted at Department of Horticulture, University of Agricultural sciences, Dharwad. Hence the study was undertaken to standardize the explants for rapid multiplication with shoot tip, auxillary buds, tubers, leaf and seed. To study the effect of growth regulators on shoot growth from auxillary buds using various cytokinins such as BAP, Kinetin, and NAA. Seeds were separated from the fruit, seed coats were separated and washed with HgCl_2 0.1 per cent for 15 minutes and then seeds were placed on Murashige and Skoog (MS) medium with 3 mg/l BAP (6- benzyl aminopurine). After 15 days the seeds were germinated. The regeneration of plants in spine gourd was achieved by culturing auxillary bud explants on MS medium with different levels of cytokinins such as BAP, NAA and kinetin. Maximum number of shoots were obtained on MS medium with 3mg per litre BAP + 0.1 mg per litre NAA. Maximum number of shoots were produced on MS medium containing 1 mg/l BAP. Similarly maximum number of shoots were rooted in MS medium with 1 mg/l of IBA. The shoots were rooted in auxin medium containing 1 mg per litre IBA. Peat medium was found to be better for the growth of plantlets. The plantlets were successfully hardened and transferred to field.

SESSION V

**BIOTIC STRESS : CURRENT SCENARIO AND
MANAGEMENT STRATEGY**

C.A. Viraktamath

Department of Entomology, University of Agricultural sciences,
GKV, Bangalore 560065

Abstract

Gherkin is a cent per cent export oriented crop grown in Karnataka, Tamil Nadu and Andhra Pradesh. The export earnings during 2013 from this crop were rupees 800 crores.

One of the major problems in growing this crop is infestation by melon fly, *Bactrocera cucurbitae* and pumpkin fly, *Dacus ciliatus*. The former is wide spread and found in gherkin growing areas whereas the latter is more restricted geographically and dominates during certain seasons only.

The economic threshold level of these pests is near zero, a challenge difficult to achieve. Normal measures recommended by various institutions can bring down incidence of the pest only to about 5% which is not acceptable by the gherkin industry and importing countries. The males of melon fly are attracted to cue-lure where as those of pumpkin flies are not attracted to any of the available lures. At present we do not have any effective female attractants other than protein hydrolysate which is not being produced in India. Therefore, studies on the behaviour of both sexes of the fly were made to develop strategies for its management.

This involved growing of trap crop as along the border of the crop (mainly maize), setting up of cue-lure pheromone traps, protein bait spray laced with permitted insecticides by the importing countries and good sanitation. In addition, wide area management was also tried to minimise the incidence of this pest to below 0.5%. One of the most important aspect was development of female attractant which could further reduce the incidence of fruit fly as much as in Wide area management area.

These tactics will be discussed and it will be emphasized that involvement all stake holders and growers is necessary to bring down the menace of fruit flies not only in cucurbits but also in other horticultural crops.

Single line trellis-An alternative strategy for pest management in smaller cucurbit

H. S Singh

Central Horticultural Experiment Station, (Indian Institute of Horticultural Research) P.O. Aiginia, Bhubaneswar-751 019, Orissa

Abstract

Cucurbits are important commercial crops in many parts of the country. These crops suffer heavily due to the attack of various pests and diseases. Cultivating the cucurbits on bower (pandal) is a common practice for growing smaller cucurbits. This practice has its inherent limitations as sunlight penetration in the interiors of the pandal is very poor, incidence of diseases and pests is more and drudgery in all inter-cultural operations is severe. Alternatively, single line trellis system as against double line trellis and bower system was designed and evaluated for smaller cucurbits with farmers' participation. The experiment was conducted for two consecutive years and bitter gourd was used as test crop.

Observations revealed that unit fruit weight of bitter gourd remained same but fruit number and yield were influenced significantly due to different trellis systems. Significantly higher fruit yield was recorded in single line followed by double line and lowest in covered bower system. Fruit loss in terms of number and weight due to fruit borer and fruit fly were significantly higher in bower system followed by double line and lowest in single line trellis system. Likewise the intensity of fruit borer larvae and downy mildew infection were significantly higher in bower followed by double line and lowest in single line trellis system. In farmers view also, the incidence of downy mildew was less and the process of onset of leaf ageing from the base of plant was delayed in single line. Results revealed that pesticides efficacy was increased in single line trellis. Due to ease in manual irrigation, fertilizer application, pesticide application, pest monitoring and weeding, the drudgery was reduced and efficiency increased in single line trellis system. Greater benefit was realized in terms of pesticide application as the target area could be fully accessed with least body exposure of the worker to pesticide drift. Observations clearly indicated that the incidence of pest was reduced by default in single line trellis system when compared to farmers practice. Cost of trellis in single line system was also less as against the farmers' practice of covered bower trellis. Later on the single line system was uptoaken by the State government in its State plan, on which the Department of Horticulture has spent Rs.1.63 crore in 11 districts of Odisha.

Major Fungal Diseases in Cucurbits in Eastern Region and their Management Strategies

Ritesh Kumar, Sudarshan Maurya, A K Singh and S.Kumar

ICAR Research Complex for Eastern Region, Research Centre, Plandu, Ranchi

Abstract

Cucurbit vegetables are widely cultivated, and share 5 to 6 % of the total vegetable production in Eastern Region (ER). In last two decades, the productivity of cucurbits in ER has increased due to introduction of fertilizer responsive high yielding hybrids/cultivars and non-conventional crops such as pointed gourd, water melon, musk melon, and long melon. The test entries of AICRP (VC) received under multi location trials in bottle gourd, sponge gourd, ridge gourd, and cucumber revealed that the fungal diseases such as damping off of seedlings, downy mildew and anthracnose in rainy season; and *Fusarial* wilt, powdery mildew and *Alternaria* leaf spot in summer season are the major diseases of cucurbits in ER. In severity, downy mildew caused greatest damage followed by *Fusarial* wilt, anthracnose, powdery mildew, damping off, and *Alternaria* leaf spot. The wilt disease of bottle gourd where none of the tested and commercial entries possesses effective resistance and fungicides like carbendazim, and thiophenate methyl do not work satisfactorily, poses highest threat in summer cultivation. Proper diagnosis and selection of appropriate fungicides are major constraints at the farmer's fields in successful management of the diseases. Cultural practices leading to the conditions that when it minimises leaf wetness to less than 6 hours at temperature favourable for diseases development such as growing cucurbits on support of trellis during not-so-intense rain, use of plastic mulching, grow in low poly tunnel are proving beneficial in management of fungal diseases infecting foliage. Raising disease free seedlings in pro-tray nurseries and grafting cucurbits on resistant rootstock such as the bottle gourd on ash gourd have shown ways for effective management of soil borne *fusarial* wilt disease at ICAR RCER, Research Centre, Ranchi. Use of microbial consortia for management of soil borne inoculum is in advance developmental stage

During the seminar it is proposed to elaborate on above scientific issues from data of AICRP (VC) and our concluded project on *Epidemiology and Forewarning system of Downy Mildew Disease of Cucurbits to develop appropriate IPM strategy.*

Bacterial diseases of cucurbitaceous crops - A status report

Dinesh Singh

Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi

Abstract

Cucurbitaceous crops are a member of family cucurbitaceae, which form an important group of vegetable crops in different parts of the world. The family cucurbitaceae contains at least 9 genera and of them 16 species are cultivated as vegetables. In India, cucurbits like ash gourd, bitter gourd, bottle gourd, cucumber, sponge gourd, long melon, or snake cucumber, kundru, muskmelon, pointed gourd, pumpkin, ridge gourd, snake gourd, squash, round gourd and watermelon are cultivated round the year in one or the other region of the country. Cucurbits are consumed in various forms i.e., salad (cucumber, gherkins, long melon), sweet (ash gourd, pointed gourd), pickles (gherkins), deserts (melons) and culinary purpose. Some of them e.g. bitter gourd are well known for their unique medicinal properties. In recent years, abortifacient proteins with ribosome-inhibiting properties have been isolated from several cucurbit species, which include momordicin (from *Momordica charantia*), trichosanthin (from *Trichosanthes kirilowii*), and beta-trichosanthin (from *Trichosanthes cucumeroides*). In India, a number of major and minor cucurbits share about 5.6 % of the total vegetable production. According to FAO estimate, cucurbits are cultivated on about 4,290,000 ha with the productivity of 10.52 t/ha. An estimate, India will need to produce 215,000 t of vegetables by 2015 to provide food and nutritional security at individual level and, being a large group of vegetable; cucurbits provide better scope to enhance overall productivity and production.

To increase the production of cucurbits a major constraint is biotic stresses particularly diseases during cultivation and after harvest and among various diseases caused by fungi, bacterial and viral diseases, bacterial diseases like bacterial wilt (*Erwinia tracheiphila* (Smith) Bergey et al.), angular leaf spot (*Pseudomonas syringae* pv. *lachrymans* (Smith and Bryan) Young et al.), bacterial leaf spot (*Xanthomonas cucurbitae* (ex Bryan) Vauterin et al.), bacterial blotch (*Acidovorax avenae* subsp. *citrulli*), and bacterial soft rot (*Erwinia carotovora* subsp. *carotovora*) cause sometimes heavy losses under ideal disease development conditions. Besides these diseases, there are some minor diseases reported on a particular crop of cucurbits and country like bacterial leaf spot on summer squash and melon (*Pseudomonas syringae* pv. *syringae*) from USA, bacterial wilt of cucumber (*P. marginalis* pv. *marginalis*) from Iran and bacterial wilt of bitter gourd and ridge guard (*Ralstonia solanacearum* race 1, biovar 3) from India. These diseases are diagnosed based on the symptoms in the field and also their related pathogens. Bacterial wilt caused by *E. tracheiphila* transmitted by

insect vectors, primarily the striped cucumber beetle (*Acalymma vittatum* (Fabricius)) and the spotted cucumber beetle (*Diabrotica undecimpunctata howardi* Barber) and other insects that cause wounds, such as grasshoppers, may also transmit the bacteria. Angular leaf spot, leaf spot and fruit blotch diseases are seed borne in nature and also survive on infected plant debris in the soil.

These causal bacteria are well characterized using classical methods like colony characters, morphological, biochemical, physiological and pathogenicity test. All these bacteria are gram negative and rod shaped. For detection and diagnosis of bacterial pathogens, some advanced techniques such as serological DNA based (PCR, RFLP & RTPCR) are used in some cases. Immunohistochemistry (ELISA) has been used for detecting *E. tracheiphila* within its vector and suggested a long-term extracellular endosymbiotic association of *E. tracheiphila* with the alimentary canal of *A. vittatum*. *Pseudomonas syringae* pv. *lachrymans* was identified by using rep-PCR and compared to isolates from field and commercial varieties of cucumber. For characterization of *Xanthomonas cucurbitae*, used advanced techniques such as amplified fragment length polymorphism and MultiLocus Sequence Analysis (MLST) for identifying the strains at the species level. Confirmation of the species primers RST2 (52 AGGCC TGGAAGGTGCCCT GGA32) and RST3 (52 ATCGCACTGCG TACCGCGCGA32) in a conventional PCR assay are used to amplify at 1,500-bp. For detection of *A. avenae* subsp. *citrulli* bacteria from seeds, a combination of immunological and PCR techniques (immuno absorb-PCR) is used to detect 1 x 10 cfu/ml. Its sensitivity is 100 times higher than that of conventional PCR and detection period is only 4 h. The BX-S primers facilitated the detection of the pathogen from washings of 5000-seed samples with 0.02% infestation. This primer set is also assessed for detection using immunomagnetic separation polymerase chain reaction (IMS-PCR) with detection level 0.02% infestation in seed samples.

The most of the bacteria survives in infected plant debris. The bacteria can spread through rain splashes and irrigation water and beetles particularly in bacterial wilt. Moisture is the most important factor governing disease development and its severity. Optimum temperature for the development of the disease is 25 to 30°C.

Bacterial wilt can be managed to a large extent by controlling vector cucumber beetles by using systemic insecticide in cucumber and melon crops in disease prone areas. Plant growth-promoting rhizobacteria (PGPR) strains INR7 (*Bacillus pumilus*), GB03 (*B. subtilis*), and ME1 (*Curtobacterium flaccumfaciens*) are tested singly and in combinations for biological control against multiple cucumber pathogen including bacterial wilt. The three-way mixture of PGPR strains (INR7 plus ME1 plus GB03) as a seed treatment showed at par to the synthetic elicitor actigard in intensive plant growth promotion and disease reduction.

For managing angular leaf pot, crop rotation with non-cucurbitaceous crops and field sanitations are essential to eliminate inoculums of the pathogen. Disease free seed may be produced in the dry areas to help in reducing the disease. Seed

borne infection can be partially reduced by soaking in antibiotics and inorganic salts. field spray on the crop either with streptomycin sulphate (100 ppm), copper fungicides, ridomil and trimiltox forte (copper oxychloride + mancozeb) are found the most effective in decreasing disease incidence and severity of the disease. The application of abiotic agents (Bion (acibenzolar-S-methyl), jasmonic acid, salicyclic acid or ethephon as foliar treatment on cucumber is found more effective than as seed treatment to decrease the disease severity. In biocontrol, two strains of plant-growth promoting rhizobacteria *Pseudomonas putida* 89B-27 and *Serratia marcescens* 90-166 induce systemic resistance (ISR) in cucumber against the disease. Three *Bacillus* strains, *B. subtilis* UMAF6614 and UMAF6639 and *B. cereus* UMAF8564, and two *P. fluorescens* strains, UMAF6031 and UMAF6033 are applied to melon seedlings and they promoted plant growth, increasing fresh weight and provided protection against this disease by reducing disease incidence. However, the interaction between biotic (*P. fluorescens* or *P. putida* isolates) as soil treatment and abiotic agents (salicyclic acid or ethephon) as foliar treatment greatly decreased the severity of the disease. The three oils such as thyme oil, fennel and carnation oils significantly controlled the disease incidence

Naturally infested seeds of pumpkin with *Xanthomonas cucurbitae* were treated in aqueous solutions of chemicals copper plus mancozeb (0.36 g+0.27 g/100 ml of water), 1% peroxyacetic acid, and 1% sodium hypochlorite for 15 min were effective in eliminating the pathogen on seed.

To control bacterial fruit blotch, currently, no chemical or physical seed treatments are 100% effective at eradicating *A. avenae* subsp. *citrulli*. While seed treatments including thermotherapy, NaOCl, fermentation, HCl and peroxyacetic acid significantly reduce the disease seedling transmission. Combining ionized copper or peroxyacetic acid in the irrigation water with a weekly foliar application of acibenzolar-S-methyl is most effective in reducing spread. To avoid introducing *A. avenae* subsp. *citrulli* into transplant houses, only tested, pathogen-free seed are planted. A nonpathogenic *A. citrulli* strain uses as seed treatment for controlling the disease. Naturally infested watermelon seed treated with *A. citrulli*, AAC00-1 DeltahrcC reduces bacterial fruit blotch seedling transmission.

The main goal of research on cucurbitaceous crops in India is to improve productivity. Proper diagnosis of the bacterial diseases in cucurbits by using advanced techniques is required. There is no bacterial resistant varieties are available, hence, it is required to include in breeding program along with other biotic stresses and quality attributes. The value-added breeding approach will add to increase the availability of vegetable by minimizing the post-harvest losses. Considering growing concerns about residue-free vegetables and export of fresh/canned vegetables, it has become imperative to shift to IPM-based practices.

Pesticide Residues in Cucurbitaceous Vegetables - Status and Management

Debi Sharma

*Pesticide Residue Laboratory, Indian Institute of Horticultural Research,
Hesaraghatta Lake P.O., Bangalore-560089*

Abstract

Cucurbitaceous vegetable crops are regarded as minor vegetable crops in terms of area under production and have been traditionally popular summer vegetables grown throughout India. These vegetables were earlier not sprayed with pesticides as these are generally low value crops. However with increasing demand for all vegetables including cucurbitaceous vegetables and increase in peri-urban horticulture, increasing amount of pesticides are being used on these crops. In India, 241 pesticides and 41 combination products are registered as on date for use in agriculture. The average pesticide consumption in India is around 381g a.i./ha as compared to world average of 500g a.i./ha. 14 per cent of pesticides used in the country are applied on vegetables, maximum use is in chilli (5.13%) followed by brinjal (4.6%). Although it is difficult to estimate the amount of pesticides used in cucurbitaceous vegetables, the common pests of these crops and the pesticides used for their control are well known.

A pesticide is registered in India by the Central Insecticide Board for use in a crop or several crops for which it is said to have a label claim. Till date, very few pesticides have the label claim for use in cucurbitaceous vegetables. Of these, Imidacloprid 70% WG is registered for control of aphids and jassids in cucumber. Trichlorfon 5% granule, 5% dust and 50% EC and Dichlorvos 76% EC have the label claim for use in control of red pumpkin beetle in cucurbits. Among fungicides, Benomyl 50% WP, Carbendazim 50% WP, Thiophanate 70% WP and Zineb can legally be used for disease management in cucurbits. Thus, a vast majority of pesticides which may be recommended for use in cucurbitaceous vegetables for control of pests may not be used on them legally.

One way to reduce harmful pesticide residues in crops is to follow prescribed waiting period. Waiting period, also called pre harvest interval, is the time required between the last application of a pesticide and the first picking of the crop for its safe consumption. However, very few studies have been conducted to recommend waiting period for harvest of safe produce on these crops. Some of the waiting period recommendations on cucumber is given in the following table,

Table 1: Waiting period of selected pesticides in cucumber

S.No.	Pesticide	Pest	Waiting period(days)	MRL(source) ppm
1.	Azoxystrobin	Downy mildew Powder mildew	4	1 (EU)
3.	Carbaryl	Cucumber beetle	14	0.01(EU)
2.	Ethion	Mites	7	0.5(EU)
4.	Imidacloprid	Aphids, jassids	3	1(EU)
5.	Spiromesifen	Red spider mites	4	0.3(EU)

Dissipation of lambda cyhalothrin 5 EC was studied in gherkin after two foliar applications viz. 1.5 and 3 ml/L at 7 day's interval each during flowering – fruit development stage. Insecticide residues could be detected upto 10 to 13 days after the last spray. The residues dissipated with half-lives of 2.7 and 3.5 days respectively from treatment at recommended and double the recommended doses while the waiting period recommended to obtain safe produce was 17 to 22 days based on the dissipation pattern of residues and the permissible level prescribed for lambda cyhalothrin residues in gherkin by EU viz. 0.1 ppm. Similarly metalaxyl and mancozeb residues when applied as their combination formulation, were found to persist for 15 days and the waiting period recommended in bitter gourd was 4 days.

In another study carried out at IIHR, residue dissipation of a fungicide dimethomorph 50 WP was evaluated in cucumber grown in polyhouse and the result was compared with dimethomorph residues in cucumber grown in open field. The fungicide was applied tank mixed with metiram 70 WG. Dimethomorph residues at deposit following application at recommended dose, dissipated within 5 days in cucumber grown in open field (OF) and within 10 days in poly house (PH), although the initial residue deposit (1.812 ppm) was lower in PH than in OF (2.064 ppm). Metiram residues required waiting period of 2 days in cucumber from field as well as polyhouse.

It is clear from available literature that very little information on pesticide residue management in cucurbitaceous vegetables exists. Codex MRLs and Indian (FSSAI) MRLs on these crops do not exist for most pesticides. In order to establish permissible levels of pesticide residues in cucurbitaceous vegetables, data needs to be generated on dissipation pattern of pesticide residues in these crops. In view of the increasing use of pesticides on these crops, more studies on establishing the rate of dissipation of pesticide residues needs to be carried out. Such studies will also identify IPM friendly pesticides that can be used on these crops at near harvest stages of crop and also establish waiting periods for harvest of safer produce.

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Characterization of begomovirus associated with yellow mosaic disease of ridge gourd in Southern India

Chandrakant V.Patil, S. V. Ramdas, K. S. Shankarappa and M. S. Kulkarni

Department of Plant Pathology, K.R.C College of Horticulture, Arabhavi-591 218,
University of Horticultural Sciences, Bagalkot, Karnataka

Abstract

Ridge gourd is an important vegetable crop in Karnataka affected several abiotic and biotic factors. Of the different biotic factors yellow mosaic disease is emerging problem. The disease incidence varied from 43 to 100 percent in six districts of northern Karnataka. The infected plant showed initial chlorosis, mosaic, upward and downward curling and cupping of leaves, blistering, reduction in leaf size and stunted growth. The disease was transmitted by whitefly *Bemisia tabaci*. All the inoculated plants produced symptoms at 8-12 days after inoculation. Transmission efficiency was 100 per cent with five or more whiteflies for each plant. *B. tabaci* requires minimum of 12 hours of acquisition access period and inoculation access period for 100 % transmission. The host range studies revealed that different crop species like *Luffa cylindrica*(sponge gourd), *Benincasa hispida*(ash gourd), *Cucurbita moschata*(pumpkin), *Cucurbita pepo* (summer squash), *Cyamopsis tetragonolobus*(cluster bean), *Nicotiana tabaccum* (tobacco), *N. benthamiana* (tobacco), *Datura stromonium* (datura) and *Cucumis sativus* (cucumber) found to be susceptible to yellow mosaic disease of ridge gourd. Polymerase chain reaction was employed to amplify fragment of coat protein gene and replicase gene, the parts of DNA-A of begomoviruses. Analysis of the coat protein gene sequence with selected begomoviruses sequences revealed that the causal virus shared the highest nucleotide sequence identity of 94.03 per cent with ToLCNDV infecting chilli from India. Phylogenetic analysis of coat protein gene showed the begomovirus associated with yellow mosaic disease of ridge gourd is grouped cluster next to the ToLCNDV infecting different crops from India.

Chemical management of powdery mildew of (*Cucumis sativus* L.)

M. R. Dabbas, Shravan Kumar and D. P. Singh

Vegetable Section, Kalyanpur, C.S. Azad Univ. of Agric. & Tech., Kanpur

Abstract

Cucumber (*Cucumis sativus* L.) is an important cucurbitaceous vegetable crop. It is thought to be one of the oldest vegetable cultivated by man with historical records dating back 5,000 years. The crop is the fourth most important vegetable

after tomato, cabbage and onion in Asia, however, second most important vegetable crop after tomato in Western Europe in tropical Africa. Cucumber crop is attacked by various plant diseases, among them Powdery Mildew of cucumber caused by *Erysiphe cichoracearum* is an important disease which effect a large area of the cucumber crop. An experiment was laid down at Vegetable Research Farm, Kalyanpur, Kanpur for disease management by chemicals and observations on disease intensity and yield was recorded in consecutive years (2011-12 and 2012-13). It is evident that minimum disease intensity (6.85% and 7.35%), maximum edible fruit yield of cucumber (221.36 and 216.19 q/ha) and maximum C: B ratio (1:2.90) were recorded in treatment (T_5) three foliar sprays of Bayliton (0.2%) at 10-12 days intervals from initiation of the disease followed by treatment (T_1) three foliar sprays of Tridemorph (calexin 0.1%), which gave (10.15 and 8.65%) disease intensity, (204.12 and 209.62q/ha) edible fruit yield and C: B ratio (1:2.45).

Fertilization of *Bactrocera cucurbitae* eggs initiates primary defense response in *Sechium edule* fruit?

P. D. Kamala Jayanthi, Vivek Kempraj, Arthi Kirubha and Ravindra Aurade

Division of Entomology and Nematology, Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangalore – 560 089

Abstract

Plants recognize insect oviposition and elicit defenses against the eggs to curtail future herbivory. But, how plants recognize oviposition and initiate defense response is a controversial subject. In order to determine the mechanism of ignition of primary defense response in insect-plant interaction, we used the oviposition behavior of *Bactrocera cucurbitae* on *Sechium edule* as a model system. Usually, female insects fertilize their eggs as they oviposit and previous studies have shown that an oxidative burst takes place during fertilization of eggs. This oxidative burst mainly involves production of hydrogen peroxide, H_2O_2 (ROS) in large quantity from fertilized eggs. The evolved H_2O_2 is used by eggs to strengthen their shells and to prevent the lethal condition of polyspermy. However, it seems that this helpful mechanism is also deleterious to the eggs themselves. In this study, we found that when *B. cucurbitae* laid eggs into *S. edule* fruits a large amount of H_2O_2 is produced (3 mM) and in turn instigates production of more H_2O_2 and Nitric oxide (NO). These ROS combination kill eggs and first instar larvae. The mRNA expression of crucial enzymes that are involved in H_2O_2 and NO production are up regulated after infestation. It was also observed that eggs did not hatch into larvae and in case they hatched, could not survive beyond the 2nd instar.

Volatiles released from mechanically damaged cucurbit fruits attract female *Bactrocera cucurbitae*

P. D. Kamala Jayanthi, Vivek Kempraj and Ravindra Aurade

*Division of Entomology and Nematology, Indian Institute of Horticultural
Research, Hessaraghatta Lake Post, Bangalore – 560 089*

Abstract

Finding of a suitable oviposition site is crucial to the fitness of female insects because it determines the successful development of their offspring. Due to heavy selection pressure for the safety of their progeny, they must adopt the most reliable volatile cues to override distortions from environmental cues. Here, we found that the melon fly, *B. cucurbitae*, uses volatiles released from cucurbit fruits upon mechanical damage as oviposition-site recognition cues. Volatiles from bitter gourd and cucumber either mechanically damaged or undamaged were collected using air-entrainment systems. These volatiles were subjected to olfactometer studies and we observed that the time spent and entries made by gravid females to the olfactometer arm containing mechanically damaged fruit volatiles were significantly higher than volatiles from undamaged fruits. Oviposition assays revealed that gravid females preferred to lay most of their eggs onto mechanically damaged fruits than undamaged ones. With this study, we find a proof that volatiles released from mechanically damaged fruits are attractive to gravid *B. cucurbitae*.

Screening of muskmelon landraces of Karnataka for downy mildew disease resistance

T. Sudhakara, Shivapriya Manchali and Amruta S. Bhat

College of Horticulture, University of Horticultural Sciences, Bengaluru- 560065, Karnataka

Abstract

Muskmelon (*Cucumis melo*, 2n = 24) is one of the most important botanical types among the highly diverse and polymorphic species of *Cucurbitaceae* family and it plays a significant role in supplying fresh fruits. Muskmelon landraces are tailored to different agro-climatic regions of Karnataka and their genetic diversity has not been explored much for crop improvement. In our study twenty eight landraces collected from different parts of Karnataka were screened for downy mildew at field condition along with IIHR 651 as a resistant check and Kashi Madhu as a susceptible

check. Each plant was visually assessed for percent leaf area infected using linear 0 to 5 scale and the Percent Disease Index (PDI) was calculated. Out of 28 landraces, four landraces were resistant to downy mildew disease (1-10 PDI), another four genotypes were moderately resistant including resistant check IIHR651(11-25 PDI), nine were moderately susceptible including susceptible check Kashi Madhu (26-50 PDI) and 13 were susceptible to downy mildew disease. The disease intensity recorded as per cent leaf area infected ranged from 8.41 per cent (COHB-011) to 73.83 per cent (COHB-019) with mean disease severity of 43.39 per cent. The resistant lines observed here could be used for further confirmation of disease resistance and for resistance gene introgression breeding.

Studies on screening of cucurbitaceous species for root knot nematode and fusarial wilt resistance

Thangamani, C¹, Pugalendhi, L²

¹ Horticultural College & Research Institute, Tamil Nadu Agricultural University, Coimbatore; ² Tapioca and Castor Research Station (TNAU), Yethapur

Abstract

An experiment was carried out at the Department of Vegetable Crops, HC&RI, TNAU to screen twelve cucurbitaceous species against root knot nematode (RKN)-*Meloidogyne incognita* and fusarium wilt-*Fusarium oxysporum* f.sp.*cucumerinum*. Inoculation was done with nematodes (5000 J₂/5kg pot) and *Fusarium oxysporum* f.sp.*cucumerinum* (culture grown in sand: maize media) under pot culture conditions. Root knot nematode screening studies in pot culture revealed that *Cucumis metuliferus*, *Citrullus colocynthis*, *Cucurbita moschata* and *Cucumis callosus* were found to be resistance to root knot nematode with a gall index of two (RKI-2), whereas, *Cucurbita ficifolia*, *Cucurbita maxima* and *Cucumis melo* sub sp. *agrestis* were found to be moderately resistant to RKN (RKI-3). Biochemical studies of cucurbitaceous species against RKN revealed that, *Cucumis metuliferus* recorded highest total phenols (16.98 mg g⁻¹) and peroxidase activity (3.83 OD min⁻¹g⁻¹) followed by *Citrullus colocynthis* (total phenols 16.08 mg g⁻¹; peroxidase activity 3.26 OD min⁻¹g⁻¹) and *Cucurbita moschata*(total phenols 15.37 mg g⁻¹; peroxidase activity 15.37 mg g⁻¹) respectively. Pot culture studies against fusarium wilt revealed that 30, 45and 60 days after inoculation of *F. Oxysporum* f.sp.*cucumerinum*, the species *Cucumis metuliferus* and *Citrullus colocynthis* were found to be immune with PDI of zero per cent up to 60 days. PDI was found to be lesser at 60 DAI in *Cucumis callosus*(12.76 %),*Cucumis melo* sub sp. *agrestis*(16.76 %),*Cucurbita ficifolia*(20.14 %), *Cucurbita moschata* (20.52 %) and *Cucurbita maxima* (29.87 %). Biochemical studies of cucurbitaceous species against *F. oxysporum* f.sp.*cucumerinum* revealed

that, highest total phenols (33.20 mg g^{-1}) and peroxidase activity ($3.76 \text{ OD min}^{-1}\text{g}^{-1}$) was recorded in *Cucumis metuliferus* followed by *Citrullus colocynthis* (total phenols 29.50 mg g^{-1} , peroxidase activity $3.22 \text{ OD min}^{-1}\text{g}^{-1}$) and *Cucurbita moschata* (total phenols 25.73 mg g^{-1} ; peroxidase activity $2.93 \text{ OD min}^{-1}\text{g}^{-1}$) respectively. From the pot culture studies it could be concluded that, *Cucumis metuliferus*, *Citrullus colocynthis*, *Cucurbita moschata* and *Cucumis callosus* were found to be resistance to root knot nematode and *Cucumis metuliferus* and *Citrullus colocynthis* were immune to *F. oxysporum* f.sp.*cucumerinum* respectively.

Evaluation of ridge gourd genotypes against Yellow Mosaic disease

S. V. Ramdas, Chandrakant V. Patil, K. S. Shankarappa and M. S. Kulkarni
Department of Plant Pathology, K.R.C College of Horticulture, Arabhavi-591 218, University of Horticultural Sciences, Bagalkot, Karnataka

Abstract

Ridge gourd is one the important vegetable crops in southern India affected by several abiotic and biotic stresses. Of the different biotic stress yellow mosaic disease is emerging problem. Begomovirus associated with yellow mosaic disease of ridge gourd. In order to identify resistance source against the yellow mosaic disease, fifty two genotypes (22 varieties and 30 hybrids) were screened under insect proof net house condition with artificial viruliferous whiteflies (*Bemisia tabaci*) inoculations. Results of the all inoculated fifty hybrids / varieties showed highly susceptible and whereas only two varieties (Rekha and Pusa Nasdar) showed a susceptible reaction. Highest infection (100% disease incidence) observed at eight weeks after inoculation of the plants in all hybrids / varieties.

Role of Cucurbits grafting to manage biotic and a biotic stress

**K. Mallikarjunarao, H.N. Mishra, G.S. Sahu,
Rojalin Pradhanand Madusmitha Beshari**
Department of Vegetable Science, OUAT, Bhubaneswar - 751 003

Abstract

Commercial grafting of vegetable plants originated at the turn of the 20th century, and the primary intent was to manage soil borne pathogens. The earliest reports from Japan included the use of *Cucurbita moschata* to confer fusarium wilt resistance

in watermelon production. Grafting as a disease management tactic has rapidly expanded to cucurbit fruiting vegetables. The primary motive for grafting cucurbits is to avoid damage caused by soil borne pests and pathogens when genetic or chemical approaches for disease management are not available. In addition, grafting provides advances to manage a biotic stress, to reduce reliance on chemical and fertilizer inputs, and to enhance fruit quality. The survival rate of grafted plants depends on compatibility between scion and rootstock, quality and age of seedlings, quality of the joined section, and post-grafting management. Successive cropping can increase salinity, the incidence of cucurbit pests, and soil borne diseases like fusarium wilt caused by *Fusarium* spp. These conditions cause various physiological and pathological disorders leading to severe crop loss. Chemical pest control is expensive, not always effective, and can harm the environment. Grafting can overcome many of these problems. Grafting is an alternative approach to reduce crop damage resulting from soil borne pathogens and increase plant biotic and abiotic stress tolerance, which increases crop production.

Effect of grafting on cucumber with cucurbitaceous rootstocks for fusarium wilt (*Fusarium oxysporum* f. sp.*cucumerinum*) and root knot nematode (*Meloidogyne incognita*) resistance

Punithaveni, V and P. Jansirani

Horticultural College and Research Institute, Tamil Nadu Agricultural University

Abstract

Cucumber (*Cucumis sativus* L.) is an important and commercially popular cucurbitaceous salad vegetable crop which holds a very specific position in the vegetable market. Today it has become the fourth important vegetable in the world, after tomato, cabbage and onion. Now a days, the successful cultivation of the crop is hampered and yield reductions are extremely high due to the serious pest root knot nematode and soil borne diseases. The most important soil borne fungal diseases is fusarium wilt, causing destructive losses in cucumber production. Chemical control of root knot nematodes and other soil borne diseases in cucumber is becoming more difficult because of increased cost of plant protection chemicals. Further, these chemicals are harmful to nearly all-living organisms and create residual action causing environmental pollution.

An alternative approach for managing this problem in cucumber is very much needed. Grafting technology in cucumber with wild/relative species as rootstock resistant or tolerant to such disease and nematode problem is addressed in many

cucumber growing countries. Hence, it is right time to standardize the grafting technology for cucumber in India also. Grafting of susceptible cultivated cucumber on resistant or tolerant rootstocks is a new approach to find solution for nematode and disease problem. Hence, a study on identification of suitable rootstock for cultivated cucumber with resistance or tolerance to fusarium wilt and root knot nematode in cucumber was taken up. The main objective of the study is to standardize the grafting technique, compatible and resistant root stock against fusarium wilt and root knot nematode.

The initial screening studies were conducted in completely randomized block design (CRBD) and replicated thrice with seven rootstocks of cucurbits as treatment viz., Fig leaf gourd (*Cucurbita ficifolia*), Pumpkin (*Cucurbita moschata*), Winter squash (*Cucurbita maxima*), Bottle gourd (*Lagenaria siceraria*), Sponge gourd (*Luffa cylindrica*), African horned cucumber (*Cucumis metuliferus*) and watermelon wild species (*Citrullus colocynthis*) and two cucumber scions NS 408 (F₁ hybrid) and Green Long (variety) to identify resistance /tolerance of the root knot nematode (*Meloidogyne incognita*) and fusarium wilt (*Fusarium oxysporum* f. sp.*cucumerinum*). Among the rootstocks screened *Cucumis metuliferus*, *Citrullus colocynthis*, *Cucurbita maxima* and *Cucurbita ficifolia* found to be resistant to root knot nematode which recorded the root knot nematode gall index (RKI) of 2.0. The rootstocks *Lagenaria siceraria* and *Luffa cylindrica* were found to be moderately resistant to RKN (RKI- 3.0). Screening study against the incidence of fusarium wilt have revealed that the rootsctoks *C. metuliferus*, *C. colocynthis* were found to be immune (PDI - 0%) to fusarium wilt with per cent disease incidence (PDI) of zero at 60 days after inoculation. However, *C. maxima* (19.67 %) *L. siceraria* (20.00 %) *C. ficifolia* (20.14 %) and *L. cylindrica*(22.22 %) have also recorded the lesser per cent of disease incidence for fusarium at 60 days after infection.

From the screening studies, though the rootstocks African horned cucumber (*Cucumis metuliferus*) and watermelon wild species (*Citrullus colocynthis*) were found to be resistant to the incidence of RKN and fusarium wilt, the stem of the rootstock is very thin when compared to cucumber seedlings (scion) which resulted in poor grafting success. So, these two rootstocks were found to be not suitable for grafting with scion of cucumber seedlings. Hence, the remaining five rootstocks viz., fig leaf gourd (*Cucurbita ficifolia*), pumpkin (*Cucurbita moschata*), winter squash (*Cucurbita maxima*), bottle gourd (*Lagenaria siceraria*), sponge gourd (*Luffa cylindrica*) were grafted with scion of Green Long (variety)and NS 408 (hybrid) cucumber (*Cucumis sativus* L.) seedlings were grafted using two different grafting methods viz.,using hole insertion grafting (HIG) and side grafting

(SG) methods using factorial completely randomized design with three replication. Grafting success per cent was investigated 15 days and 30 days after grafting.

The results have revealed that the highest graft success per cent was recorded in the hole insertion grafting method with NS 408 (85.81% and 82.36%) and Green Long (85.00% and 82.35%) grafted on bottle gourd rootstock on 15 and 30 days after grafting respectively. The lowest graft success per cent in HIG was recorded in the grafting of NS 408 (70.84% and 68.50%) and Green Long (70.65% and 68.30%) scion on sponge gourd rootstock on 15 and 30 days respectively.

In side grafting the highest graft success per cent of 42.80 and 40.38 was reported in the graft combination of NS 408 and Green Long grafted on pumpkin rootstock respectively on 15 days after grafting while the NS 408 and Green Long grafted on sponge gourd rootstock recorded the graft success per cent of 35.50 % and 33.30 % on 30 days after grafting respectively. In SG, the lowest graft success per cent was recorded in NS 408 (29.52% and 16.45%)and Green Long (29.35% and 15.35%) grafted on fig leaf gourd on 15 and 30 days after grafting respectively.

The successful grafted plants obtained from Hole Insertion Grafting (HIG) method was transplanted to main field in randomized block design and replicated thrice for evaluation of yield and quality. Two scions grafted on five rootstocks along with two non-grafted plants (scion) which were kept as a control. Among the ten graft combinations the NS 408 grafted on Fig leaf gourd rootstock recorded the highest yield of 8.40 kg of fruits per plant with more number of fruits (20.57) followed by NS 408 grafted on winter squash recorded the highest fruit yield of 7.22 kg per plant and number of fruits of 18.94. The lowest yield recorded in the graft combination of Green Long grafted on sponge gourd (2.59 kg per plant) and Green Long grafted on pumpkin (2.27 kg per plant) with 7.51 and 8.74 number of fruits per plant respectively. The non-grafted plants of NS 408 and Green Long recorded the yield of 3.84 kg and 2.93 kg per plant and 12.83 and 10.47 number of fruits per plant respectively.

Hence it could be concluded that, among the different root stocks *Cucurbita maxima* (winter squash)and *Cucurbita ficifolia* (Fig leaf gourd) were found to be moderately resistant to fusarium wilt and root knot nematode and these two rootstocks suitable for grafting with cucumber. Among the two grafting methods, hole insertion grating method could be used successfully for cucumber with the highest survival rate. Hence, these rootstocks could be used for cucumber against fusarium wilt and root knot nematode resistance in cucumber.

Predominant viruses of minor cucurbits in Odisha

**P. Srinivas, M. Krishna Reddy¹, S. Mandal, G Sangeetha,
L.K. Bharathi and H.S. Singh,**

*Central Horticultural Experiment Station (IIHR)
Aiginia, Bhubaneswar -751019, Odisha; ¹Indian Institute of
Horticultural Research, Bengaluru
Email: sripost@gmail.com*

Abstract

Family Cucurbitaceae comprises several edible melons and gourds popular worldwide. These crops make an integral part of the traditional food and medicine both to the native and rural folks in India. In this eastern state of India, huge variability is present in cucurbits as a whole. Odisha is endowed with wide genetic variability of cucurbits, comprising of several species endemic to the area. Central Horticultural Experiment Station (IIHR), Bhubaneswar has collected a gene pool of different cucurbitaceous crops and also come up with elite varieties for ivy gourd, teasel gourd and spine gourds. However, the garmplasm and varieties have been observed to be affected by varying degree of viral infection. The viral diseases are serious threat to the production potential of the affected crops. Plant samples affected by the symptoms of viral diseases were collected from the germplasms and varieties of cucurbitaceous crops in CHES, Bhubaneswar. The symptoms varied from severe mosaic like patterns in ivy gourd, mottling of leaves and mosaic in sweet gourd, mild to moderate mosaic in teasel gourd, to mild mosaic spots in C1 hybrid between teasel gourd and spine gourd. The diagnosis of the samples at Indian Institute of Horticultural Research, Bengaluru revealed that the C1 hybrid line and Ivy gourd cv. sabuja were infected with PRSV (papaya ring spot virus) and ToLCND virus (tomato leaf curl new delhi virus). Besides these minor cucurbits bitter gourd with symptoms of shortening of leaves and mosaic was also found to be affected by ToLCND virus. Diagnosis of the teasel gourd and sweet gourd samples are yet to be confirmed. However, presence of heavy population of white flies in the dense foliage of crops there may be a threat of rapid spread of ToLCND virus in future large scale cultivation. Effect of the virus disease on the yield potential of the selected crops needs to be undertaken.

SESSION VI

**INDUSTRIAL AND ENTREPRENEURSHIP POTENTIAL AND
CHALLENGES FOR CUCURBIT PRODUCTS AND
PRODUCTION OF PLANTING MATERIAL**

Hari Har Ram

Ex-Vice-President-R&D-Krishidhan Vegetable Seeds India Pvt. Ltd, Pune

Abstract

Cucurbits occupy an important place as popular vegetable crops in India. The crops included in this group have tremendous diversity and are adapted to a wide range of environmental conditions covering tropical, sub-tropical regions, arid deserts and temperate regions. A total of 15 cucurbitaceous vegetable/fruit crops grown in India and under active research include ash or wax gourd, bitter gourd, bottle gourd, cucumber, Indian squash, muskmelon, pointed gourd, pumpkin, ridge gourd, snake gourd, sponge gourd, vegetable marrow, long melon, snap melon and water melon. Based on various statistics available, it is estimated that the area of cucurbits in India is 0.43 million ha with a production of 4.5 million tonnes and productivity of 10.46 tonnes/ha. The corresponding figures at global level are 8.5 million ha, 179.0 million tonnes and 20.97 tonnes/ha. Obviously, productivity of cucurbits in general in India is about half of the productivity globally. This is ironical on the ground that massive research efforts in terms of deployment of competent manpower and matching resources have been put in place at the country level. This paradox is further compounded by the fact that several cucurbits, namely, cucumber, ridge gourd, sponge gourd, sweet gourd, round melon, snake gourd and pointed gourd have their primary centre of origin in India. Except cucumber from this list, all other crops are research responsibility of perhaps India alone as no other country consumes these on a wider scale.

ICAR institutes engaged on vegetable research and departments of Horticulture and Vegetable Science in state agricultural and lately a few horticultural universities have put in tremendous efforts on plant genetic resources management, registration of novel germplasm with National Bureau of Plant Genetic Resources, introduction of elite lines and varietal development both in terms of pure-lines/open-pollinated cultivars and recently the hybrids. The documented information on these issues speaks volumes but the concrete results in terms of boosting productivity are not to be seen in tangible manner. Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation announced a new seed policy on import of seed/planting material on September, 16, 1988 for the benefit of all the stake holders concerned with seed. The new seed policy came into effect on 1 October, 1988 and opened up the doors to private seed companies for import and marketing of vegetable seeds and also for in-house research and development programmes by these companies and accordingly today about 200 vegetable seed companies (multi-nationals, joint-ventures and Indian) are fully engaged in vegetable crop research and development, seed production, seed processing and packaging and seed marketing on a big scale.

Problems and Prospects of Gherkin Cultivation Through Contract Farming in India

B.V. Ramakrishna

Co-ordinator, APEDA funded Gherkin R&D Project,
Department of Entomology, University of Agricultural Sciences,
GKV, Bangalore – 560 065

Abstract

Gherkin, *Cucumis sativus* L belonging to family cucurbitaceae is commonly called as small cucumber or pickling cucumber is consumed as a condiment in Western World along with bread, meat and beverages. Gherkin crop was first introduced in Karnataka during early 1990's, gradually it became a very popular crop among the small farmers. Later it has spread to neighboring states like Andhra Pradesh and Tamil Nadu. Gherkin export from India during 1997-98 was 24,290 MTs valued at Rs.50 crores. Now, during 2013-14 it has reached 2,18,750 MTs with a value of Rs. 955 crores. Absence of local demand for gherkin fruits, the companies are able to procure the entire crop produce and export, this is one of the main reason why the contract farming of gherkins has been successful compare to any other crop.

Gherkin is being grown in India under contract farming engaging 1.30 lakhs small and marginal farmers by gherkin processing companies. Gherkin companies enter into an agreement with the growers providing buy back guarantee at pre-agreed prices depending on the grade of fruits. Today gherkin contract farming is considered to be one of the socio-economically successful agricultural crop model in India. Contract farmers receive technical support, seeds, fertilizers, pesticides and buy back guarantee at farm-gate at pre-agreed prices. Presently export of processed gherkins is being done by 54 companies, of which 28 are in Karnataka, twenty-one in Tamil Nadu, three in Andhra Pradesh and one each in Maharashtra and Gujarat. Processed gherkins are exported in bulk as industrial raw material and in jars as ready to eat. Gherkins are exported to more than 20 countries, mainly USA, Canada, Russia, Europe, U.K., Australia etc.

Indian gherkin industry's **strengths** are: gherkin export companies mobilizing a dedicated extension team, many willing farmers with small and medium holding who mainly depend on family labors. Year round suitable climate (10 month) for gherkin cultivation, capable of supplying small sized gherkins, government support, fruits quality conforms to internationally accepted quality standards. **Weaknesses** are: low crop yields (Germany – 40 MTs per acre, Turkey – 12 MTs per acre, Vietnam – 10 MTs per acre, USA – 5 MTs per acre, India – 3.5 MTs per acre), pest and diseases damage, dependence on the foreign companies for seeds, short power supply, long dry spells. **Opportunities** are: expansion to newer areas with congenial climate to

meet increasing demand, adoption of precision farming for higher yields, development of new varieties in India to reduce cost of seeds, since seeds are being presently imported, improved processing and packaging technology to meet changing consumer tastes, establishing new processing units, thus creating job opportunities at local level. Present **threats** to the gherkin industry are: less margin to farmers, increase in cost of cultivation, fruit fly menace, low pesticide import tolerance and stringent import norms by the importing countries

Since this industry has created direct, indirect and tertiary employment opportunities to local farm labor, transport operators, extension workers, labor force in processing units, shipments, traders, shop keepers etc., Government of India and state governments are also supporting this industry in the form of transport assistance, capital subsidy and fruit fly control subsidy. University of Agricultural Sciences, Bangalore with APEDA, New Delhi financial support has recently standardized the gherkin crop production technology for cultivation of export quality gherkins.

Post harvest processing, better shelf life, easy transport, packaging and marketing of cucurbits

T.R.Gopalakrishnan¹ and Saji Gomez²

¹*Director of Research, Kerala Agri University, Thrissur,* ²*Asst. Professor, College of Horticulture, KAU, Vellanikkara*

Abstract

Cucurbitaceous vegetables are grown largely during summer months and are widely consumed all over India. The post-harvest handling and processing operations for many of these cucurbitaceous vegetables are specific and therefore, suitable techniques are to be formulated for their maximum utilization in order to prolong their shelf life, improve quality and for diversification of value added products. Pre harvest cultural and environmental factors have pronounced effect on post-harvest quality and shelf life of vegetables. Pre harvest sprays of bitter gourd and cucumber with plant growth regulators like GA, CCC, MH and ethephon significantly influenced fruit length, girth, yield/plot, fruit qualities and shelf life. Cucumbers should be harvested when they are horticulturally mature i.e. at an immature stage; near full size but before the seeds fully enlarge. The main method used to measure harvest maturity is fruit size. Fruit that are too mature have a tough leathery skin and are bitter in flavour. Ridge gourd is harvested when it is sufficiently tender without formation of tough texture, whereas pumpkin and ash gourd are harvested at fully developed stage. In all pumpkin varieties, an improvement in quality was evidenced by high carotene, TSS, total sugars and acidity was observed when harvest was delayed up to 60 days after anthesis.

All vegetables continue their metabolic processes even after harvest. In order to check these metabolic activities, vegetables should be quickly precooled soon after harvest. As cucurbits are mostly warm season vegetables, care should be taken that the precooling temperature is not very low as it can result in chilling injury to the produce. Hydrocooling has the additional advantage of cleaning and sanitization of the produce when chlorine is incorporated in wash water. But this method is not advised for cucurbits not suited to wetting (pumpkin, ash gourd, cantaloupes etc. Washing cucurbits to remove the adhering dirt and dust is an inevitable practice as most of the cucurbits are in direct contact with soil when they are grown in open field conditions. The fruits can be dipped in a wash tank with chlorine 150 ppm, sodium hypo chlorite or calcium hypochlorite. After cleaning, the fruits must be placed on clean perforated trays or wire mesh surface to remove excess surface moisture. Washing is not practiced in cucurbits like pumpkin, snake gourd and ash gourd. Cucurbits are mainly graded based on size, shape, colour, evenness of shape and appearance.

Though cucurbits in general are comparatively cheaper vegetables, high value cucurbits like cucumber and squashes (summer and winter) can be subjected to waxing as they fetch higher prices in the market. Food grade liquid waxes can be applied on cucurbits, particularly, those with even surface like cucumber so as to extend shelf life and also to improve market appeal. Waxes like Semperfresh, Stay fresh, Carnauba wax, when applied on fruit surface will retard respiratory activity, prevent moisture loss by reducing transpiration. In India scant attention is being devoted to packaging of vegetables, particularly cucurbits, wherein they are handled in bulk and loaded into sacks directly from the field and transported in trucks by road. High value cucurbits like slicing cucumber, bitter gourd, squashes, ridge gourd, musk melon, cantaloupe etc. can be packaged in corrugated fibre board boxes. Shrink packaging can be adopted in high value cucurbits like cucumber, squashes etc. Packaging of ivy gourd fruits in polypropylene 80 gauge and polyethylene 150 gauge films, were found to be the superior treatments for extended marketability and reduced weight loss. Packaging resulted in less than 1 % moisture loss when stored at ambient temperature for six days.

Cucurbits, being tropical vegetables require an optimum storage temperature above 10°C (50° F) so as to avoid chilling injury to the produce. In general, cucurbits can be safely stored at a temperature range of 10-15° C and the relative humidity ranges from 70-95 %. Though some cucurbits have hardy fruits (pumpkin and ash gourd), waxy coating (cucumber, ash gourd), moisture loss occurs from these vegetables in spite of these features. Therefore, most of the cucurbits require a relative humidity above 90 % to prevent moisture loss from their surfaces, with the exception of pumpkin and ash gourd wherein, the optimum relative humidity recommended is

around 70 %. Studies conducted at KAU revealed that refrigeration of bitter gourd fruits after treatment with 400 ppm of CCC was found to retain quality during storage. The storage life of cucumber could be extended to 3 weeks at 10° C by pre-packing in flexible films with retention of freshness and tenderness.

Marketing of cucurbits is generally of two types: 1) those marketed with low levels of moisture (pumpkin, ash gourd) and stored at low humidity to avoid post-harvest decay or 2) those marketed with high moisture levels and stored at high humidity (cucumber, bitter gourd, ridge gourd etc.). Market demand for cucurbits varies according to consumer preferences and it varies from region to region. However specific varieties with long keeping quality and good market acceptance has been identified in various cucurbits.

Developing technologies for value addition and reducing post-harvest losses by adopting on farm primary processing and minimal processing are viable alternatives that hold promise in the days to come. In cucurbits, primary processing techniques are employed to a lesser extent in case of pumpkin and ash gourd.

Experiments on dehydration of bitter gourd proved that sun drying, dehydration in cabinet drier, dehydration after treatment with 4 % brine and intermediate moisture bitter gourd were found promising. Ivy gourd lines with bitter fruits were found to be suitable for pickle making, after curing with sodium chloride (15%). Small fruited types of cucumber, particularly the whole fruits of gherkin (*Cucumis anghuria*) are preferred in the processing industry for brining and pickling purposes. KAU has developed technologies for development of osmotically dehydrated pumpkin and ash gourd chunks, pumpkin flakes, pickles from pumpkin, bitter gourd and ivy gourd etc.

. Water melon rind pickle prepared from dried and cured pieces in 3-4 % salt, mixed with spices and oil, was found to have a shelf life of six months at ambient temperature. Ash gourd candy, popularly known as 'Agra petha' is widely available all over India.

Efficient post-harvest management of vegetables begin in the field itself through Good Agricultural Practices (GAP) and it should always be borne in mind that quality cannot always be improved post-harvest. High quality and better shelf life of vegetables depend upon sound production practices, appropriate handling during harvest and adequate post-harvest handling, packaging, storage and transportation.

Scope of Micro-entrepreneurship for Seed and planting material production in Cucurbits

Dr.P.T.Umashankar¹

¹*Agro-economist (formerly consultant with The World Bank, Asian Development Bank, National Horticulture Board, RKVY, Department of Agriculture and Cooperation, GOI), Centre for Ecology and Economics, Chennai-20*

Backdrop: With 179.9 million hectares, 20 agro-climatic regions, 46 of the 60 soil types, India holds the second largest and most varied agricultural land in the world. Its food grain production is at an all time high of 264.38 million tonnes as per third advance estimates for the year 2013-14 and its horticultural production scaling to 280.77 million tonnes (with 60.6% share from vegetables at 170.25 million tonnes). However, the contribution of agriculture in total GDP of the country is about 12-14% which is fairly un-matching with the 60-65% of the total population depending directly or indirectly on agriculture for their livelihood.

Deficiency to Sufficiency in Food: While India can boast itself from being a deficient to sufficient food producing country for its people, the availability of vegetables in India is only 260g/capita/day as against the recommended dietary allowance of 300g/capita/day with the post harvest loss estimates ranging from 10-30%. Also, considering the varying prices of vegetables, taste and preferences, purchasing power, and perishable nature, its consumption is far below to a vast majority of its population.

Vegetable Cultivation: The most urgent need today is to increase the production of nutritious food in a sustainable manner and improve farm income to ensure household food and nutritional security, while conserving the natural resource base. Vegetable production gains significance not only for its nutritional security point of view, but also for its high income and employment generation, particularly for small and marginal farmers. With limited scope for horizontal expansion, vertical expansion by way of improved yields is the key issue that need to be addressed.

Vegetable Consumption: With technological advancements, the production targets of vegetables is not a distant dream; however, the real challenge lies in making it affordable for the buyer, while the producers interests are not compromised. Cucurbits or gourds as they are popularly called offer a fill up by way its affordable availability and uncompromising returns to the producer.

Gourd Vegetables: Cucurbits or gourds are probably one of the earliest domesticated types of plants (archaeological evidence dates as early as 13,000 BC). They had numerous uses throughout history, including as tools, musical instruments, objects of art, apart from food. Cucurbit crops are mostly produced for their immature

or mature fruits. However, a relatively high proportion of cucurbit fields are destined for seed production, either for seed consumption or for propagation material. Production of cucurbits for seed consumption (as a snack food) is very popular in some parts of the globe and almost unknown in others.

Production of Gourd Vegetables in India: The share of cucurbits is around 5% of the total vegetable production of India (5.6% as per a recent FAO estimate) and the trend is more or less static. The edge of cucurbits over the other vegetables is because of its low calorie and high nutrition. As India grows to be the diabetic capital of the globe, gourd vegetables offer immense opportunities in the culinary composition of diabetics. Research has progressed in a great deal to remove the bitterness in certain gourds yet retaining its other properties offering an improved choice for customers.

Unlike, most vegetables, gourds survive well under summer and drought condition and the key to its expansion lies in constant and uninterrupted supply of seed and seed material for their cultivation.

Value Addition and Exports: At present, value addition in cucurbits is very much restricted. Also, most cucurbits are cultivated for domestic supplies; hardly cucurbits are cultivated for seeds. With the WTO and GATT regime, export possibilities for non-traditional vegetables saw have opened up. Crops like Cucumbers, Gherkins, Pumpkins saw huge increase in exports (for instance Cucumber and Gherkin exports from India to Pakistan rose from 12.53 MT worth Rs.1.78 lakhs during 2011-12 to 681.47 MT worth Rs.181.36 lakhs during 2013-14). The facilitating regimes of the seed bill can also facilitate export of quality seeds if they are produced to meet the global standards.

Seed Production in Cucurbits: In many places, small and marginal farmers retain their seeds for further cultivation. Wherever, seed production is taken up, unlike major multi-nationals, a large number of medium and small scale entrepreneurs take up seed production to cater to the domestic demands. Some of these agencies are also investing in R&D to develop improved and new varieties.

Scope for Micro entrepreneurship in Crop and Seed Production: In conventional seed production, the agency or a contract farmer takes up seed production (for certified seeds) and sells back the seeds for a prefixed price. In this model, the contract farmer is an intermediary in the process and loses out on the scope of vertical value addition benefits. Therefore, a new model to integrate crop production as well as seed production under three levels of technology and investment are suggested.

The process, levels of technology and investment, their distribution and roles involved in the supply chain process and value addition are elucidated for piloting and adoption. Suitable policy and enabling environment and investment thrust initiatives are also suggested to support this model.

Antioxidant rich fruit fractions from *Momordica spp.* and their commercial potential in functional food industry

Shrawan Singh¹, L. K. Bharathi²

¹Division of Horticulture & Forestry

Central Island Agricultural Research Institute, Port Blair-744101, Andaman and Nicobar Islands.; ²Central Horticultural Experiment Station, Bhubaneswar

Abstract

The mining for lycopene rich natural sources and understanding the factors for variable expression level of this trait in such sources is very interesting topic among the related researchers. This is due to high free radical quenching capacity of the lycopene and strong evidences that lycopene has anti-cancer property particularly against prostate cancer. Though, tomato is universal source of lycopene for different food items but *Momordica cochinchinensis* also emerged as richest source of lycopene for industrial use. It has been claimed that the aril fraction of *M. cochinchinensis* contains around 70 times higher lycopene than tomato. The present paper reviews the significant contributions in the field of biochemistry, health studies and industrial uses of lycopene from *Momordica spp.* and presents future strategies for utilization of other lesser known or under-utilized *Momordica* plants through research and industrial interventions.

Alleviation of type 2 diabetes by Bitter gourd fruit extract (BGFE) in humans

Prarthana Mohanty, P. Ashok, K. Sasikala and D. V. Swami

Horticultural College & Research Institute, Dr. Y.S.R Horticultural University,
Venkataramanagudem-534 101, Andhra Pradesh

Abstract

Type 2 diabetes mellitus is rapidly becoming a dominant disease around the world. The World Health Organization reports that worldwide the number of people affected with type 2 diabetes is 240 million. The international Diabetes Foundation reports 285 million people were fully affected by diabetes and 400 million with pre-diabetes. It is predicted that each year, an additional 8-10 million people will develop the disease. This disease fully exploited in countries like India, China and United States. Patients with diabetes mellitus have a higher risk of cardiovascular disease. Therefore, a reduction in all cardiovascular risks such as dyslipidemia, hypertension and being over-weight is advisable. Despite remarkable advances made in the management of diabetes by the use of synthetic drugs, there has been a renewed interest in medicinal plants because generally they do not elicit any side effects. Plants or their extracts such as *Momordica charanita* (Bitter gourd) has been widely used as an traditional medicine treatment for diabetics patients in Asia. Experiments on animals with bitter gourd fruit extract exhibited hypoglycaemic effects. Bitter gourd possess insulin – like properties increase insulin secretion, increase tissue glucose uptake, Preserved pancreatic islet α cells, decrease glucose absorption, increase liver and muscle glycogen storage, depress hepatic gluconeogenesis and improve the activity of key enzymes of the glycolytic pathway. Studies indicated that it has emerged as one of our strongest botanical interventions for improving blood glucose. The science and native wisdom behind the plant show its value in treating type 2 diabetes mellitus. Bitter gourd seeds contain momorcharin, which have been antifertility effects. The most appropriate or effective dose of bitter gourd is not entirely clear. Each capsule contained 500mg of dried powder of the fruit pulp and contained 0.04%-0.05% of charantin. Clinical trials need to conduct to exploit the full extent of its medicinal properties.

Possibilities for Establishment of Processing and Value Addition Units of Ash Gourd (*Benincasa hispida*L.) for Improving Livelihood of Tribal Farmers of Bastar Division of Chhattisgarh

Deo Shankar¹, M. K. Sahu², S. C. Mukherjee¹, G P. Nag³, and Kamal Narayan⁴

¹ S.G College of Agriculture and Research Station, Kumhrawand, Jagdalpur - 494 005

²SMS, Horticulture, Krishi Vigyan Kendra (IGKV) Narayanpur, Chhattisgarh

³Scientist (Horticulture) College of Horticulture, (IGKV) Jagdalpur - 494 005

⁴SMS, Horticulture, KrishiVigyanKendra (IGKV) Dantewada (C. G)

Abstract

A conventional survey was conducted in seven different districts (Bastar, Dantewada, Bijapur, Sukma, Kondagaon, Narayanpur and Kanker) of Bastar Division of Chhattisgarh during the year 2013-2014 for collection of information about ethnic or local use of Ash Gourd by local people and collection of data about sowing time, fruit weight, selling price, fruit setting per plant, fruit yield per plant, mode of consumption of ash gourd, awareness about *petha* preparation, total area and production. The Ash Gourd also known as *Rakhiya*. The result of the survey about ethnic uses of Ash Gourd are indicated that the mature fruit pulp used for preparation of *Badi* after mixing of black gram pulse, mature seeds are used for preparation of *Bijauri* after mixing of seasamum seeds and tender fruits are used for preparation of vegetable. The *rakhiyabadi* used as a medicine by local people after delivery. The results of conventional survey are indicated that the total area of Ash Gourd in Bastar division is 210.50 hectare with total production 7350 tonnes with average productivity 35.00 t ha⁻¹. The major sowing time of Ash Gourd in Bastar division is Kharif season. The ash groud growers adopted all improved cultivation practices in Bastar division on upland farming situation in kharif season. The selling price of Ash Gourd fruits was 150-300/- per pair in local markets of Bastar division. Fruit weight ranges from 5-14 kg, fruit setting recorded 7-12 fruits per plant and fruit yield recorded 65-112 kg per plant. Farmers were aware about *petha* preparation but lack of expertness and training about *petha* preparation unable to start processing units of Ash Gourd in Bastar division of Chhattisgarh. All the Ash Gourd growing farmers participated in conventional survey were interested for area expansion of Ash Gourd after establishment of medium and small scale processing units. It may be concluded that on the basis of data observed during conventional survey the Bastar division of Chhattisgarh is highly potential area for establishment of Ash Gourd processing and value addition units which may be helpful for improvement of rural economy and livelihood security of tribal people of Bastar division of Chhattisgarh.

Sasmita Priyadarsini Dash, Jitendra Singh and Padmakshi Thakur

Department of Horticulture, Indira Gandhi KrishiViswavidyalaya, Raipur - 492012

Abstract

Spine gourd (*Momordica dioica* Roxb.) belongs to the family Cucurbitaceae and under the genus *Momordica*, a perennials climbers. Spine gourd is commonly known as kakrol, kankada, kankro, kartoli etc. The average nutritional value per 100 g edible fruit was found to contain 81.4% moisture, 7.7 g carbohydrates, 3.1 g fat, 3.0 g fiber and 1.1 g minerals. Its green fruit contain 12-14 % protein. Spine gourd is rich in calcium, phosphorous, iron, carotene and the fruit contain a high amount of vitamin-c. It is rich in fiber and vitamins and used to making sabzi or curries in India. It has many beneficial medicinal properties, cooling to the body, easy to digest, well for cough, fevers, increase appetite and good for kidney. Recent research show that it good for diabetes. The consumption of green fruit and tuber stimulate the activities of pancreas and control the level of sugar. Although it considered as underutilized and minor cucurbitaceous vegetable, it is widely cultivated in Orissa, Chhattisgarh, Maharashtra, Bihar and West Bengal and is slowly gaining popularity as a commercial vegetable crop because of its taste and high nutritional value. Spine gourd has prominent position among the cucurbitaceous vegetable owing to its good nutritional value and medicinal value, high keeping quality, ability to withstand long distance transportation, high market price and good export potential.



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कृषि मंत्रालय भारत सरकार

N-1/303,आई.आर.सि.भिलेज,नयापल्ली, भुबनेश्वर-751015(ଉडिशा)

टेली/फैक्स नं. -(0674)-2558134

ई.मेल:nhbbsr@gmail.com, वेब साइट:www.nhb.gov.in

Revised Operation Guidelines for release of subsidy in respect of projects under NHB Schemes

With a view to promote horticulture (in open field area above 02 Hectors (i.e. above 5.00 acres) and in Protective cultivation area 2500 Sq.mtr) and creation of critical infrastructure for the sector and to reduce the interest burden on the loan taken by the farming communities/ entrepreneurs on projects considered under the credit linked back ended subsidy scheme of the Board, Operational Guidelines have been revised (Annexure-I and II, Chapter-III) for the release of subsidy. Following are the broad parameters governing this procedure.

- a) Procedure for submission of documents/papers for final subsidy claim to the Board:
 - i) The concerned FI/Bank which has provided credit for the project shall submit subsidy claim in prescribed format as under to respective office of NHB as under:
 - To respective State Office of NHB upto the project cost of Rs.50.00 lakh.
 - To NHB, HQ, Gurgaon where the project cost is above Rs.50.00 lakh.
 - ii) Upon release of 50% installment of term loan by bank to promoter, NHB would release 100% subsidy to the concerned bank/FI as per prevailing cost norms.
 - iii) The subsidy would be kept frozen by bank/FI in the Subsidy Reserve Fund Account (SRFA) of the NHB.
- b) Final subsidy claim on completion of project and upon release of final withdrawal of term loan by the Bank/FI.

A Joint Inspection Team (JIT) consisting representative from bank, NHB, State Hort./

Agri. Department will conduct joint inspection of the project to settle the final subsidy claim based on eligible project cost on the basis of all the relevant parameters and approval of appropriate committee of NHB.

- c) Documents to be submitted with the subsidy claims:
 - i) Financial appraisal report of the bank.
 - ii) Term loan sanctioned letter issued by the bank with detailed terms and conditions.
 - iii) Term loan disbursement schedule for the project.
 - iv) Extract of term loan account of promoter.
 - v) Affidavit in Format-IV.
 - vi) Release of at least 50% of term loan into project Bank loan account.
 - d) Documents to be submitted with final subsidy claim.
- Final subsidy claim shall be submitted to the Branch Office of NHB or to the Head Office, NHB as the case may be, along with following documents.
- i) Completion Certificate by Bank/FI.
 - ii) Term loan disbursement details (date-wise).
 - iii) Statement of Expenditure incurred certified by bank for project costing upto Rs.50.00 Lakh or by Chartered Accountant (CA), if project cost exceeds Rs.50.00 Lakh.

Other Provisions:

- i) The subsidy so granted to the lending banks/FIs shall be deemed as estimated (tentative) only. Final amount shall be determined on the basis of the Joint Inspection Team by the Approval Committee on completion of the project.
- ii) The subsidy will be adjusted by bank only after receiving the written advice of NHB for this purpose and balance amount would be refunded to NHB within 30 days. For any delay beyond it, bank will be liable to pay interest on the refundable amount.
- iii) Requirement of application for the Letter of Intent (LOI) will be voluntary for the promoter and would be issued only on the request of the promoter. This will not be required for claim of subsidy.
- iv) It is expected that the lending bank would undertake necessary inspections(s) and technical & financial appraisal to ensure that the project is new, meets the guidelines of NHB, and the promoter has clear land title or lease hold right over the land before the release of term loan.
- v) In case the project is not completed within 18 months from the date of release of estimated (tentative) subsidy, the project would be eligible for nay subsidy, unless the promoter has sought extension of time from NHB under unavoidable or exceptional circumstance. In such cases, the bank would refund the subsidy to NHB expeditiously or not later than 30 days after such period.
- vi) The decision of NHB with regard to eligibility and interpretation of the guidelines shall be final and binding on the beneficiaries and banks.
- vii) These guidelines would come in force with immediate effect.

Revised Operation Guidelines for LOI in respect of Horticulture projects (in open field area above 02 Hectors (above 5.00 acres) and in Protective cultivation area 2500 Sq.mtr) under NHB Schemes

Further, as NHB/DAC has revised the procedure for subsidy claims wherein issuance of Letter of Intent (LOI) is voluntary, there may be instances to get LOI approval to facilitate bank/FI term loan or for some other reasons, the procedure/documents to be submitted for LOI is being simplified, as below:-

(Upto Project Cost Rs.50.00 Lakh at NHB, Bhubaneswar and more than Rs50.00 Lakh at NHB (HQ), 85/18, Gurgaon)

- i) Application form in prescribed format – I.
- ii) Prescribed cost of Application.
- iii) Certified Copy of record of rights over the piece of project land. In case of lease of land for the project a certified copy of lease deed which should be registered at the time of submission of LOI application.
- iv) Detailed Project Report (DPR).
- v) Consent letter by the lending bank.
- vi) Affidavit.

Pattern of assistance

- I) **In Open filed cultivation:-** Credit linked back-ended subsidy @ 40% of the total project cost limited to Rs 30.00 lakh per project in general area and @ 50% of project cost limited to Rs. 37.50 lakh in NE Region, Hilly and Scheduled areas.
- II) **In Protective cultivation:-** Credit linked back-ended subsidy @ 50% of the total project cost limited to Rs 56.00 lakh per project as per admissible cost norms for green houses, shade net house, plastic tunnel, anti bird /hail nets & cost of planting material etc.
- III) **In PHM/Primary Processing:-**Credit linked back-ended subsidy @ 35% of the total project cost limited to Rs 50.75 lakh per project in general area and @ 50 % of project cost limited to Rs. 72.50 lakh per project in NE, Hilly and Scheduled areas.

General conditions

- I. Credit component as means of finance of the project should be term loan from banking or non banking financial institutions and should not be less than 25% of eligible project cost.
- II. Normative cost of various components shall be prescribed by NHB.
- III. Benefit of exclusive components of cold storage scheme shall also be available to the promoters over and above the assistance that will be provided under Commercial Horticulture Scheme to set up integrated projects for production and PHM components.
- IV. Projects relating to setting up of new units shall be technically and financially appraised to ensure and enable entrepreneur to incorporate latest available technology.
- V. Assistance can also be availed for a combination of PHM infrastructure components by a beneficiary, within the prescribed norms of individual items.

For more details please contact:

National Horticulture Board, (Ministry of Agri.Govt.of India),
Plot No.N1/303, IRC Village, Nayapalli, Bhubaneswar-751015, Ph/Fax no.(0674) 2558134
E-mail:www.nhbbsr@gmail.com. Web site: www.nhb.gov.in

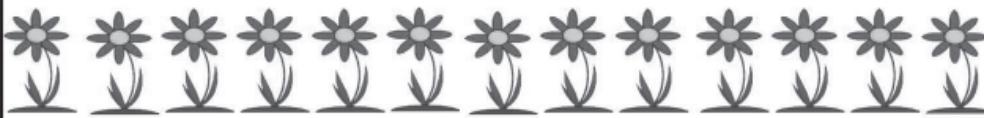
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Plot No: 3915, Shop No: 07, In front of Kedar Gouri Temple,
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3	9.05	2,450/-	
4	9.05	1,730/-	
5	8.75	1,340/-	
6	8.75	1,060/-	
7	8.75	870/-	
8	8.75	730/-	
9	8.75	610/-	
10	8.75	530/-	

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MISSION:

Promotion of sustainable and equitable agriculture and rural development through effective credit support, related services, institution development and other innovative initiatives.

MAJOR ACTIVITIES

- Credit Functions : Refinance for production credit (Short Term) and investment credit (Medium and Long Term) to eligible Banks and financing institutions
- Development Functions : To reinforce the credit functions and make credit more productive, development activities are being undertaken through
 - ✓ Research and Development Fund
 - ✓ Micro Finance Development and Equity Fund (MFDEF)
 - ✓ Financial Inclusion Fund (FIF)
 - ✓ Financial Inclusion Technology Fund (FITF)
 - ✓ Farm Innovation and Promotion Fund (FIPF)
 - ✓ Farmers' Technology Transfer Fund (FTTF)
 - ✓ Watershed Development Fund (WDF)
 - ✓ Rural Infrastructure Development Fund (RIDF)
 - ✓ Tribal Development Fund (TDF)
 - ✓ Cooperative Development Fund (CDF)
 - ✓ Rural Innovation Fund
- Supervisory Functions: NABARD shares with RBI certain regulatory and supervisory functions in respect of Cooperative Banks and RRBs.
- Provides consultancy services relating to Agriculture & Rural Development (nabcons@vsnl.net)



**NABARD Head Office - Plot No. C-24, G-Block, Bandra Kurla Complex,
Post Box No- 8121, Bandra (E), Mumbai – 400051, visit us at : www.nabard.org**

Committed to Rural Prosperity



CENTRAL HORTICULTURAL EXPERIMENT STATION
(Indian Institute of Horticultural Research)
Aiginia, Bhubaneswar-751019, Odisha