ABOUT IJBMBR

The International Journal for Biotechnology and Molecular Biology Research (IJBMBR) (ISSN 2141-2154) is published Monthly (one volume per year) by Academic Journals.

International Journal for Biotechnology and Molecular Biology Research (IJBMBR) provides rapid publication (monthly) of articles in all areas of the subject such as Green energy from chemicals and bio-wastes, Studies in the graft copolymerization of acrylonitrile onto cassava starch by ceric ion induced initiation, Antimutagenic activity of aqueous extract of Momordica charantia, Ethnomedicinal plants and other natural products with anti-HIV active compounds and their putative modes of action etc.

The Journal welcomes the submission of manuscripts that meet the general criteria of significance and scientific excellence. Papers will be published shortly after acceptance. All articles published in IJBMBR are peer-reviewed.

Submission of Manuscript

Please read the Instructions for Authors before submitting your manuscript. The manuscript files should be given the last name of the first author

Click here to Submit manuscripts online

If you have any difficulty using the online submission system, kindly submit via this email ijbmbr@academicjournals.org.

With questions or concerns, please contact the Editorial Office at ijbmbr@academicjournals.org.
Editors

Prof Atagana, Harrison
Institute for Science and Technology Education
University of South Africa

Prof. UC Banerjee
Department of Pharmaceutical Technology
(Biotechnology)
National Institute of Pharmaceutical Education and Research
Punjab, INDIA

Dr. Y. Omid
Faculty of Pharmacy,
Research Center for Pharmaceutical Nanotechnology,
School of Advanced Biomedical Sciences,
Tabriz University of Medical Sciences,
Tabriz, Iran.

Prof. Mohamed E. Wagih
University of New Brunswick (UNB-SJ),
Saint John College, NB,
E2L 4L5, Canada

Dr. Sripada M. Udupa
ICARDA-INRA Cooperative Research Project,
International Center for Agricultural Research in the Dry Areas(ICARDA), B.P. 6299,
Rabat Institutes, Rabat, Morocco

Dr. Amjad Masood Husaini
Sher-e-Kashmir University of Agricultural Sciences & Technology
Boholchipora, Dr. Ali Jan Road,
Nowshera, Srinagar, J&K-190011, India

Dr. Om Prakash Gupta
Directorate of Wheat Research (ICAR)
Post Box-158, A
grasain Marg, Karnal-132001,
Haryana, India

Editorial Board

Dr. Amro Hanora
Suez Canal University, Department of Microbiology and Immunology,
Faculty of Pharmacy, Suez Canal University,
Box 41522 Ismailia, Egypt

Dr. C. Rajasekaran
VIT University
School of Bio-Sciences & Technology (SBST)

Dr. Yasar Karadag
Gaziosmanpasa University
Faculty of Agriculture,
Department of Field Crops, Tokat-Turkey

Dr. Ahmet Tutus
KSU (Kahramanmaras Sutcu Imam University)
Faculty of Forestry,
Department of Forest Industrial Engineering,
Kahramanmaras 46100 Turkey

Dr. Vinod Joshi
Desert Medicine Research Centre,
Indian Council of Medical Research
New Pali Road, Jodhpur, India

Dr. Eshrat Gharaei Fathabad
K.M.18 Khazarabad road,
Sari, Mazandaran, Iran

Dr. Shashideep Singhal
121 Dekalb Ave, Brooklyn,
NY 11201, New York, USA

Dr Masayoshi Yamaguchi
101 Woodruff Circle, 1305 WMRB,
Atlanta,Georgia 30322-0001,USA

Dr. Okonko Iheanyi Omezuureike
Department of Virology,
Faculty of Basic Medical Sciences,
College of Medicine,
University College Hospital,
Ibadan, Nigeria

Dr. S. M. Shahid
University of Karachi,
Karachi-75270, Pakistan
<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Chethan Kumar M</td>
<td>Post Graduate Departments of Bio-technology and Biochemistry, Ooty Road, Mysore - 570 025, Karnataka, India</td>
</tr>
<tr>
<td>Dr. M. Sattari</td>
<td>Rice Research Ins. of Iran, Iran</td>
</tr>
<tr>
<td>Dr. Zaved Ahmed Khan</td>
<td>VIT University, India</td>
</tr>
<tr>
<td>Dr. Subbiah Poopathi</td>
<td>Vector Control Research Centre, Indian Council of Medical Research (Ministry of Health &amp; Family Welfare, Govt. of India), Medical Complex, Indira Nagar, India</td>
</tr>
<tr>
<td>Dr. Reyazul Rouf Mir</td>
<td>International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru - 502 324, Greater Hyderabad, India</td>
</tr>
<tr>
<td>Dr. Prasanna Kumar S</td>
<td>Virginia Commonwealth University, USA</td>
</tr>
<tr>
<td>Dr. Naseem Ahmad</td>
<td>Plant Biotechnology Laboratory, Department of Botany, Aligarh Muslim University, Aligarh- 202 002, (UP), India</td>
</tr>
<tr>
<td>Dr. Zhen-Xing Tang</td>
<td>Food Bioengineering institute, Hangzhou Wahaha Co. Ltd, Hangzhou, Zhejiang, China</td>
</tr>
<tr>
<td>Dr. Jayanthi Abraham</td>
<td>VIT (Vellore Institute of Technology) University, Tamilnadu, India</td>
</tr>
<tr>
<td>Dr. Gobianand Kuppnanan</td>
<td>National Institute of Animal Science, South Korea</td>
</tr>
<tr>
<td>Dr. R. Harikrishnan</td>
<td>Jeju National University, South Korea</td>
</tr>
<tr>
<td>Dr. Asit Ranjan Ghosh</td>
<td>Vellore Institute of Technology (VIT) University, School of Bio Sciences &amp; Technology, Medical Biotechnology Division, Vellore-632014, India</td>
</tr>
<tr>
<td>Dr. Kamal Dev</td>
<td>Shoolini University of Biotechnology and Management Sciences (SUBMS), India</td>
</tr>
<tr>
<td>Dr. Wichian Sittiprapaporn</td>
<td>Mahasarakham University, Thailand</td>
</tr>
<tr>
<td>Dr. Vijai Kumar Gupta</td>
<td>Molecular Glycobiotechnology Group, Department of Biochemistry, School of Natural Sciences, National University of Ireland, Galway, Ireland</td>
</tr>
<tr>
<td>Dr. Jeffy George</td>
<td>Department of Microbiology and Immunology, F. Edward Hébert School of Medicine, Uniformed Services University of the Health Sciences, 4301 Jones Bridge Road, Bethesda, MD 20814, USA.</td>
</tr>
<tr>
<td>Dr. Gyanendra Singh</td>
<td>Stanley S. Scott Cancer Center, School of Medicine, Louisiana State University Health Sciences Center, New Orleans, LA 70112, USA.</td>
</tr>
<tr>
<td>Dr. Anupreet Kour</td>
<td>1620 Chevy Chase Dr., Champaign, IL 61821, USA.</td>
</tr>
</tbody>
</table>
Dr. Arun Sharma  
*Institute for Plant Genomics and Biotechnology (IPGB)*  
Borlaug Center,  
TAMU 2123  
Texas A&M University  
College Station, TX 77843  
USA.

Dr. Mohsen Asker  
*Microbial Biotechnology Dept.*  
National Research Centre  
Cairo,  
Egypt.

Dr. Elijah Miinda Ateka  
*Department of Horticulture,*  
Jomo Kenyatta University of Agriculture and Technology (JKUAT)  
Kenya.

Dr. Jozélio Freire De Carvalho  
*Faculdade de Medicina Da USP, Reumatologia*  
Av. Dr. Arnaldo, 455 - 3º andar – Sala 3133.  
São Paulo - SP  
Brazil

Dr. Premendra Dhar Dwivedi  
*Food Toxicology Division*  
*Industrial Institute of Toxicology Research,*  
Post Box No: 80, Mahatma Gandhi Marg,  
Lucknow 226001,  
India

Dr. Muhammad Abd El-Moez El-Saadani  
*Universities and Research Center District,*  
*New Borg El-Arab,*  
P.O.Box: 21934 Alexandria,  
Egypt.

Dr. Donald J. Ferguson  
*Advanced Orthodontic Training Program,*  
*Nicolas & Asp University College*  
Dubai,  
UAE

Dr. Kalyan Goswami  
*Department of Biochemistry & JB Tropical Disease Research Centre,*  
*Mahatma Gandhi Institute of Medical Sciences,*  
Sevagram, Wardha-442102

Dr. A.K. Handa  
*National Research Centre for Agroforestry,*  
Gwalior Road, JHANSI-284003 UP  
India.

Dr. Amjad M.Husaini  
*Metabolic Engineering & Biotechnology Laboratory Division of Plant Breeding & Genetics*  
*Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir*  
J&K-191121,  
India

Dr. Vinod Joshi  
*Laboratory of Virology & Molecular Biology,*  
*Desert Medicine Research Centre,*  
Pali Road, Jodhpur-342 005,  
India

Dr. T. Kalaivani  
*D/O S. Thiagarajan*  
B-43, Rajaram Nagar,  
Salem - 636 007,  
Tamil Nadu, India

Dr. Priya Kalia  
*Orthopaedic Research Unit,*  
*Department of Surgery,*  
*Cambridge University, Cambridge,*  
*UK*

Dr. Patricia Khashayar  
*Tehran University of Medical Sciences*  
*Endocrinology and Metabolism Research Center*  
*Shariati Hospital*

Dr. Zaringhalam Moghadam  
*Shahid Beheshti Medical University (M.C)*  
*Tehran,*  
*Iran*

Dr. Okeke Ikechukwu Linus  
*Department of Surgery, University of Ibadan*  
*Nigeria.*

Dr. Rajesh Kumar Patel  
*Centre for Analysis and Learning in Livestock and Food (CALF)*  
*National Dairy Development Board (NDDB)*  
*Anand- 388 001 (Gujarat)*  
*INDIA*
Dr. Pooja Ralli-Jain  
*Department of Pathology and Laboratory Medicine, University of California Irvine, Irvine, California, U.S.A.*

Dr. Meltem Sesli  
*College of Tobacco Expertise, Turkish Republic, Celal Bayar University 45210, Akhisar, Manisa, Turkey*

Dr. Reda H. Sammour  
*Tanta University, Faculty of Science, Tanta, Egypt*

Dr. Seyed Soheil Saeedi Saravi  
*Mazandaran University of Medical sciences, Sari, Iran*

Dr. R. Senthil Kumar  
*St. Matthew’s University, School of Medicine, Grand Cayman Islands*

Dr. Mohammad Reza Shakibaie  
*Kerman University of Medical Sciences, Kerman, Iran*

Dr. Srividya Shivakumar  
*Dept of Microbiology, CPGS, Jain university, Bangalore*

Dr. Shashideep Singhal  
*The Brooklyn Hospital Center, NewYork-Presbyterian Healthcare System, Brooklyn, NY.*

Dr. Sripada M. Udupa  
*International Center for Agricultural Research in the Dry Areas (ICARDA), B.P. 6299, Rabat Instituts, Rabat, Morocco.*

Dr. Wei Wu  
*Institute for Biocomplexity and Informatics, Department of Bio Science, The University of Calgary, Canada*

Dr. Xiao-Bing Zhang  
*Molecular Regeneration Laboratory, MC1528B, 11234 Anderson Street, Loma Linda, CA 92350*

Prof. Dr. Ozfer Yesilada  
*Inonu University, Faculty of Arts and Sciences, Department of Biology, 44280 Malatya, Turkey*

Dr. Edson Boasquevisque  
*Universidade do Estado do Rio de Janeiro- UERJ, Av 28 de setembro, 87, fundos (LMMC-IBRAG), Vila Isabel, city: Rio de Janeiro/ RJ Brasil*

Dr. Abhilash M.  
*The Oxford College of Engineering, Hosur Road, Bangalore - 560068*

Dr. Nasar Uddin Ahmed  
*Department of Genetics and Plant Breeding, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh*

Dr. Mervat Morsy El-Gendy  
*Chemistry of Natural and Microbial Products, Department, National Research Center, Dokki, Cairo, Egypt*

Dr. Gjumrakch Aliev  
*Health Science and Healthcare Administration Program, University of Atlanta, Atlanta, Georgia, USA*

Dr. Muhammad Asgher  
*Department of Chemistry and Biochemistry, University of Agriculture, Faisalabad, Pakistan*

Dr. Anand Bharatkumar  
*Parul Institute of Pharmacy, Limda, Waghodia, Vadodara*
<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Chinmoy Kumar Bose</td>
<td>Netaji Subhash Chandra Bose Cancer Research Institute</td>
</tr>
<tr>
<td></td>
<td>16A, Park Lane, Park Street, Kolkata 700 016, India.</td>
</tr>
<tr>
<td>Dr. Mousumi Debnath</td>
<td>Jaipur Engineering College and Research Centre (JECRC) Department of Biotechnology, Shri Ram ki Nangal, Via Vatika, Tonk Road, Jaipur-303905, India</td>
</tr>
<tr>
<td>Dr. Dolan C. Saha</td>
<td>Dept. of Biochemistry and Molecular Biology, Faculty of Medicine, University of Calgary, Canada</td>
</tr>
<tr>
<td>Dr. Ramasamy Harikrishnan</td>
<td>Department of Aquatic Biomedical Sciences</td>
</tr>
<tr>
<td></td>
<td>School of Marine Biomedical Science</td>
</tr>
<tr>
<td></td>
<td>College of Ocean Sciences</td>
</tr>
<tr>
<td></td>
<td>Jeju National University</td>
</tr>
<tr>
<td></td>
<td>Jeju city, Jeju 690 756, South Korea</td>
</tr>
<tr>
<td>Dr. Abdul Haque</td>
<td>Health</td>
</tr>
<tr>
<td></td>
<td>Biotechnology division, nibge, Faisalabad, Pakistan</td>
</tr>
<tr>
<td>Dr. Kuvalekar Aniket Arun</td>
<td>Interactive Research School for Health Affairs (IRHSA), Bharati Vidyapeeth University, Pune, Maharashtra, India</td>
</tr>
<tr>
<td>Dr. Asit Ranjan Ghosh</td>
<td>School of Bio Science &amp; Technology, Division of Medical Biotechnology, Vellore Institute of Technology (VIT) University, Vellore-632014, India</td>
</tr>
<tr>
<td>Dr. Prasanna Kumar Santhekadur</td>
<td>Department of Human and Molecular Genetics, Virginia Commonwealth University, Richmond, VA</td>
</tr>
<tr>
<td>Dr. Majid Sattari</td>
<td>Rice Research Institute of Iran, Iran</td>
</tr>
<tr>
<td>Dr. Mihael Cristin Ichim</td>
<td>National Institute Research and Development for Biological Sciences / “Stejarul” Research Centre for Biological Sciences, Alexandru cel Bun St., 6, Piatra Neamţ, 610004, Romania</td>
</tr>
<tr>
<td>Dr. Sailas Benjamin</td>
<td>Enzyme Technology Laboratory, Biotechnology Division, University of Calicut, Kerala - 673 635, India</td>
</tr>
<tr>
<td>Dr. Sreeramanan Subramaniam</td>
<td>School of Biological Sciences, Universiti Sains Malaysia (USM), Minden Heights, 11800, Penang, Malaysia</td>
</tr>
<tr>
<td>Dr. Vijai Kumar Gupta</td>
<td>Department of Biochemistry, NUI, Galway, Ireland</td>
</tr>
<tr>
<td>Dr. Vítor Engrácia Valenti</td>
<td>Universidade Federal de São Paulo, Rua Napoleão de Barros, 715, Térreos, São Paulo, SP, Brazil</td>
</tr>
<tr>
<td>Dr. Ravindra Pogaku</td>
<td>Universiti Malaysia Sabah, 88999 Kota Kinabalu, Sabah, Malaysia</td>
</tr>
<tr>
<td>Dr. Ahmed Eid Abdel-Hamid Eweis Fazary</td>
<td>School of Pharmacy, College of Medicine, National Taiwan University, Taipei 100, Taiwan</td>
</tr>
<tr>
<td>Dr. Mohammad Hashemi</td>
<td>Dept. of Clinical Biochemistry, School of Medicine, Zahedan University of Medical Sciences, Zahedan, Iran</td>
</tr>
</tbody>
</table>
Dr. Hesham, Abd El-Latif  
Genetics Department,  
Assiut University, Assiut 71516, Egypt.

Prof. Jia-ying Xin  
College of Food Engineering  
Harbin University of Commerce  
138 Tongda Road  
Daoli District  
Harbin 150076, Heilongjiang  
P.R.China

Dr. Kabir Mohammad Humayun  
Plant Molecular Biotech Lab  
Department of Medical Biotechnology  
College of Biomedical Science  
Kangwon National University  
Kangwon-do, Chuncheon, 200-701  
South Korea

Dr. Kalpesh Gaur  
Geetanjali College of Pharmaceutical Studies Manwa Khera,  
Udaipur- 313002. Rajasthan, India

Dr. Meganathan, Kannan  
Center for Biologics Evaluation and Research (CBER), U.S. Food and Drug Administration (FDA),  
Bldg. NIH 29A, Room 2C-10,  
8800 Rockville Pike,  
Bethesda, MD 20892. USA.

Assist. Prof. Ali Karadeniz  
Department of Physiology,  
Faculty of Veterinary Medicine,  
University of Atatürk 25240 ERZURUM  
Turkey

Dr. Matthew Kostek  
Department of Kinesiology  
University of Connecticut  
Storrs CT

Dr. Tansu Kucuk  
Gulhane School of Medicine  
Department of Obstetrics and Gynecology  
Etilk 06018 Ankara, Turkey

Dr. Kuo-Sheng Hung  
Department of Neurosurgery  
Taipei Medical University - Wan Fang Medical Center  
111 Section 3, Hsing-Long Rd,  
Taipei 116, Taiwan

Dr. V. Manju  
Department of Biochemistry,  
Periyar University,  
Salem -11.

Dr. Mbagwu Ferdinand Nkem  
Department of Plant science and Biotechnology,  
Faculty of Science,  
Imo State University  
Nigeria.

Dr. Anand Pithadia  
Parul Institute of Pharmacy  
Vadodara, Gujarat, India

Dr. Radhakrishnan Ramaraj  
Department of Internal Medicine  
University of Arizona  
Tucson 85724  
AZ

Dr. M. Rasool  
School of Bio Sciences and Technology,  
VIT University,  
Vellore-632104, Tamil Nadu, India

Dr. Reda A.I. Abou-Shanab  
Genetic Engineering & Biotechnology Research Institute (GEBRI)  
Mubarak City for Scientific Research and Technology Applications  /New Burg El-Arab City, Universities and Research Institutes  
Zone, P.O. 21934, Alexandria, Egypt.

Dr. MR. Pravin Babarao Suruse  
Department of Pharmaceutics  
Sharad Pawar College of Pharmacy  
Wanadongri, Hingna Road  
Nagpur- 441 110. (M. S.)
Dr. Jan Woraratanadharm  
GenPhar, Inc.,  
Mount Pleasant,  
SC

Dr. Serap Yalin  
Mersin University Pharmacy Faculty  
Department of Biochemistry, Mersin  
Turkey

Dr. YongYong Shi  
Bio-X Center,  
Shanghai Jiao Tong University,  
Hao Ran Building, 1954 Hua Shan Road,  
Shanghai 200030,  
PR China

Dr. Jyotdeep Kaur  
Department of Biochemistry,  
Post Graduate Institute of Medical Education and Research (PGIMER),  
Chandigarh

Dr. Rajkumar  
Dept. Of Radiation Biosciences,  
Institute of Nuclear Medicine and Allied Sciences  
Brig. S.K. Mazumdar Road, Timarpur,  
Delhi-110054  
India

Dr. Meera Sumanth  
Visveswarapura Institute of Pharmaceutical Sciences,  
22nd Main, 24th Cross, B.S.K II stage,  
Bangalore-560070  
Karnataka,  
India.

Dr. Jai S. Ghosh  
Department of Microbiology,  
Shivaji University,  
Kolhapur 416004,  
India

Prof. Dr. Alaa H. Al-Charrakh  
Babylon University, College of Medicine.  
Dept. of Microbiology  
Hilla, Iraq
Instructions for Author

Electronic submission of manuscripts is strongly encouraged, provided that the text, tables, and figures are included in a single Microsoft Word file (preferably in Arial font).

The cover letter should include the corresponding author's full address and telephone/fax numbers and should be in an e-mail message sent to the Editor, with the file, whose name should begin with the first author's surname, as an attachment.

Article Types
Three types of manuscripts may be submitted:

Regular articles: These should describe new and carefully confirmed findings, and experimental procedures should be given in sufficient detail for others to verify the work. The length of a full paper should be the minimum required to describe and interpret the work clearly.

Short Communications: A Short Communication is suitable for recording the results of complete small investigations or giving details of new models or hypotheses, innovative methods, techniques or apparatus. The style of main sections need not conform to that of full-length papers. Short communications are 2 to 4 printed pages (about 6 to 12 manuscript pages) in length.

Reviews: Submissions of reviews and perspectives covering topics of current interest are welcome and encouraged. Reviews should be concise and no longer than 4-6 printed pages (about 12 to 18 manuscript pages). Reviews are also peer-reviewed.

Review Process
All manuscripts are reviewed by an editor and members of the Editorial Board or qualified outside reviewers. Authors cannot nominate reviewers. Only reviewers randomly selected from our database with specialization in the subject area will be contacted to evaluate the manuscripts. The process will be blind review.

Decisions will be made as rapidly as possible, and the Journal strives to return reviewers’ comments to authors as fast as possible. The editorial board will re-review manuscripts that are accepted pending revision. It is the goal of the AJMR to publish manuscripts within weeks after submission.

Regular articles
All portions of the manuscript must be typed double-spaced and all pages numbered starting from the title page.

The Title should be a brief phrase describing the contents of the paper. The Title Page should include the authors' full names and affiliations, the name of the corresponding author along with phone, fax and E-mail information. Present addresses of authors should appear as a footnote.

The Abstract should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The Abstract should be 100 to 200 words in length. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited. Following the abstract, about 3 to 10 key words that will provide indexing references should be listed.

A list of non-standard Abbreviations should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelled out and introduced in parentheses the first time it is used in the text. Only recommended SI units should be used. Authors should use the solidus presentation (mg/ml). Standard abbreviations (such as ATP and DNA) need not be defined.

The Introduction should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific disciplines.

Materials and methods should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Capitalize trade names and include the manufacturer's name and address. Subheadings should be used. Methods in general use need not be described in detail.
**Results** should be presented with clarity and precision. The results should be written in the past tense when describing findings in the authors' experiments. Previously published findings should be written in the present tense. Results should be explained, but largely without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the Results but should be put into the Discussion section.

**The Discussion** should interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include subheadings, and when appropriate, both sections can be combined.

**The Acknowledgments** of people, grants, funds, etc should be brief.

**Tables** should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed double-spaced throughout, including headings and footnotes. Each table should be on a separate page, numbered consecutively in Arabic numerals and supplied with a heading and a legend. Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented in both table and graph form or repeated in the text.

**Figure legends** should be typed in numerical order on a separate sheet. Graphics should be prepared using applications capable of generating high resolution GIF, TIFF, JPEG or Powerpoint before pasting in the Microsoft Word manuscript file. Tables should be prepared in Microsoft Word. Use Arabic numerals to designate figures and upper case letters for their parts (Figure 1). Begin each legend with a title and include sufficient description so that the figure is understandable without reading the text of the manuscript. Information given in legends should not be repeated in the text.

**References:** In the text, a reference identified by means of an author's name should be followed by the date of the reference in parentheses. When there are more than two authors, only the first author’s name should be mentioned, followed by ‘et al’. In the event that an author cited has had two or more works published during the same year, the reference, both in the text and in the reference list, should be identified by a lower case letter like ‘a’ and ‘b’ after the date to distinguish the works.

Examples:

Abayomi (2000), Agindotan et al. (2003), (Kelebeni, 1983), (Usman and Smith, 1992), (Chege, 1998; 1987a,b; Tijani, 1993,1995), (Kumasi et al., 2001)

References should be listed at the end of the paper in alphabetical order. Articles in preparation or articles submitted for publication, unpublished observations, personal communications, etc. should not be included in the reference list but should only be mentioned in the article text (e.g., A. Kingori, University of Nairobi, Kenya, personal communication). Journal names are abbreviated according to Chemical Abstracts. Authors are fully responsible for the accuracy of the references.

Examples:


**Short Communications**

Short Communications are limited to a maximum of two figures and one table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 100 words; (2) instead of a separate Materials and Methods section, experimental procedures may be incorporated into Figure Legends and Table footnotes; (3) Results and Discussion should be combined into a single section.

Proofs and Reprints: Electronic proofs will be sent (email attachment) to the corresponding author as a PDF file. Page proofs are considered to be the final version of the manuscript. With the exception of typographical or minor clerical errors, no changes will be made in the manuscript at the proof stage.
**Fees and Charges:** Authors are required to pay a $650 handling fee. Publication of an article in the International Journal for Biotechnology and Molecular Biology Research is not contingent upon the author's ability to pay the charges. Neither is acceptance to pay the handling fee a guarantee that the paper will be accepted for publication. Authors may still request (in advance) that the editorial office waive some of the handling fee under special circumstances.

**Copyright: © 2013, Academic Journals.**
All rights Reserved. In accessing this journal, you agree that you will access the contents for your own personal use but not for any commercial use. Any use and or copies of this Journal in whole or in part must include the customary bibliographic citation, including author attribution, date and article title.

Submission of a manuscript implies: that the work described has not been published before (except in the form of an abstract or as part of a published lecture, or thesis) that it is not under consideration for publication elsewhere; that if and when the manuscript is accepted for publication, the authors agree to automatic transfer of the copyright to the publisher.

**Disclaimer of Warranties**
In no event shall Academic Journals be liable for any special, incidental, indirect, or consequential damages of any kind arising out of or in connection with the use of the articles or other material derived from the UBMBR, whether or not advised of the possibility of damage, and on any theory of liability. This publication is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, or non-infringement. Descriptions of, or references to, products or publications does not imply endorsement of that product or publication. While every effort is made by Academic Journals to see that no inaccurate or misleading data, opinion or statements appear in this publication, they wish to make it clear that the data and opinions appearing in the articles and advertisements herein are the responsibility of the contributor or advertiser concerned. Academic Journals makes no warranty of any kind, either express or implied, regarding the quality, accuracy, availability, or validity of the data or information in this publication or of any other publication to which it may be linked.
ARTICLES

Research Articles

Effects of harvesting stage and storage duration on postharvest quality and shelf life of sweet bell pepper (Capsicum annuum L.) varieties under passive refrigeration system
Dargie Tsegay, Bizuayehu Tesfaye, Ali Mohammed, Haddis Yirga and Andnet Bayleyegn

Diversity analysis of sugarcane genotypes by microsatellite (SSR) markers
Smiullah, Farooq Ahmed Khan, Aqeel Afzal, Abdullah, Ambreen Ijaz and Usman Ijaz
A laboratory experiment was carried out to determine the effects of harvesting stages (0, 25, 50, 75 and 100% fruit colourations) and storage durations (0, 1, 2, 3 and 4 weeks) on physicochemical quality and shelf life of two greenhouse sweet pepper varieties (Telmo-Red and Velez-Yellow) under passive refrigeration system (PRS). The aim of the study was to identify the optimum stage of maturity at harvest and storage period under PRS that can ensure better quality and longer shelf life of two greenhouse sweet pepper varieties. The experiment was arranged in 2 x 5 x 5 factorial combinations in complete randomized design (CRD) with three replications. Thirty (30) fruits of sweet pepper were packed in card-board boxes for each treatment and stored under PRS optimum storage conditions. Fruits were assessed for weight loss percentage, fruit firmness, total soluble solids, titratable acidity, postharvest decay percentage and shelf life. Total soluble solids were increased; whereas fruit firmness decreased with increasing harvesting stages. Weight loss percentage, postharvest decay percentage and shelf life increased; while fruit firmness decreased with increasing storage periods. Telmo variety showed significantly better postharvest quality and storability potential than Velez variety.

**Key words:** Harvesting stage, postharvest, passive refrigeration system, sweet bell pepper.

**INTRODUCTION**

Sweet bell pepper (*Capsicum annuum* L.) is one of the most commercially important horticultural crops grown in tropical and sub-tropical regions of the world. From the nutritional point of view, peppers are generally considered as a balanced source of most of essential nutrients, high content of vitamins, important antioxidants, rich in flavonoids and phytochemicals (Maria et al., 2010). Sweet peppers are currently the object of much attention due to possible links to prevention of certain types of cardiovascular diseases, atherosclerosis, cancer, haemorrhage, delaying of ageing process, avoiding cholesterol, improving physical resistance and increasing appetite (Marin et al., 2004).

Growing and marketing of fresh produce is complicated by high postharvest losses which are estimated to reach as high as 25-35% of the produced volume for vegetables (Agonafir, 1991). Sweet peppers like other vegetables are quite perishable, about 28.6 and 38.7% post-
harvest losses were reported during the dry and wet seasons, respectively (Tunde-Akintunde et al., 2005). Optimum temperature and relative humidity can be achieved using passive refrigeration system (PRS) cooling machine, which is a very efficient technique to store and transport products. The system works without ventilation thus assuring shelf life which is better than the active refrigeration system equipment. The thermal autonomy allows the storage and transport without use of power during operations (Nomos, 2008).

However, there is no available scientific literature regarding the effect of harvesting stages and storage durations on retaining the postharvest physicochemical quality properties of sweet bell pepper varieties under passive refrigeration system storage condition. The main objective of the present study was to evaluate the effect of harvesting at different maturity stages and storing in PRS, on shelf life and quality of sweet bell pepper varieties.

MATERIALS AND METHODS

Experimental design and treatments

The treatments were comprised of two varieties of sweet pepper (Telmo and Velez) picked at five harvesting stages (0, 25, 50, 75, 100% coloures) and stored for five storage durations (0, 1, 2, 3, and four weeks) under PRS. The treatments were combined in CRD factorial experiment, resulting in a total of 50 treatment combinations (2x5x5) with three replications and 150 total observations (2x5x5x3). Each treatment consisted of 30 fruits packed in standard cardboard boxes for storage under PRS.

Experimental procedures

Fruits of two sweet pepper varieties with similar size (160 g) and shape (bell shaped) were harvested from Hawassa Jittu Horticulture PLC greenhouse. Maturity stages of fruits were determined by fruit colouration guide and days from anthesis. Fruits were harvested manually with care to minimize mechanical injuries. After harvest, fruits were immediately transported using standard plastic crates to packing house within 10 min and held at 10°C pre-cooling room overnight. Fruits with bruises, sign of infection or those different from the group were discarded from the samples. Fruits were washed with tap water, surface dried with soft cloth and subdivided, sorted, and weighed in the packing house; thereafter stored under PRS (model DS-TP-001-03) on three shelves as replication. Samples were taken to food technology laboratory for quality analysis. The treatments were tested at test room environmental conditions (20°C temperature and 70% relative humidity) combined with 24 h lighting to assess the shelf life of fruits after removing from the PRS.

Data collection

Weight loss percentage (WLP)

Five sweet pepper fruits were weighed at day zero and in each storage duration using sensitive balance. The difference between initial and final weight of fruits was considered as total weight loss during storage interval and expressed as percentage (AOAC, 2007):

\[
WLP = \frac{\text{Initial} - \text{Final Weight}}{\text{Initial Weight}} \times 100\%
\]

Fruit firmness

Firmness of three fruits was measured using a computer-controlled automatic fruit texture analyzer (model: TA-LEVEL-05) according to Manolopoulou et al. (2010). The firmness measurement was carried out using a cylindrical stainless steel probe of 2 mm in diameter. Puncture tests were taken from the two opposite equatorial sides of the same fruit.

Total soluble solids (TSS)

Juice of sweet pepper fruits was extracted from three fruits in a blender as described by Antoniali et al. (2007). The homogenized sample was filtered using funnel with filter paper in a beaker. The filtrate was taken for TSS determination using digital refractometer (model: RFM-860, Japan) in °Brix by placing a few drops of clear juice on the prism surface.

Titratable acidity (TA)

10 ml of juice was extracted from three fruits and then homogenized and filtered using funnel with filter paper in a beaker. The TA was measured using NaOH (0.1 N) as a standardized titration solution. When the end point of titration was reached at pH 8.2, the amount of NaOH used on the burette was read off and recorded to calculate TA:

\[
TA = \frac{\text{Titre} \times 0.1\text{NaOH} \times 0.67}{1000} \times 100\%
\]

Postharvest decay percentage (PDP)

Fruits were visually evaluated for symptoms of decay at the end of each storage interval based on the method prescribed by El-Mougy et al. (2012). Samples having symptoms of chilling injury and of diseases were counted. Pathogens causing chilling injury were not identified.

\[
PDP = \frac{\text{Number of Decayed Fruits}}{\text{Number of Total Fruits}} \times 100\%
\]

Shelf life

Shelf life of fruits was evaluated by counting the number of days required to attain fruits remaining still acceptable for marketing as described by Rao et al. (2011). It was decided based on the appearance and spoilage of fruits. When 50% of fruits showed symptoms of shrinkage and spoilage due to pathogens and chilling injury, lots of fruits was considered to have reached end of shelf life.

Statistical analysis

Data were subjected to ANOVA using SAS software version 9.
Table 1. Interaction effect of harvesting stage and storage duration on mean weight loss percentage of sweet pepper fruits under passive refrigeration system.

<table>
<thead>
<tr>
<th>Harvesting stage (%)</th>
<th>Storage duration (weeks)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0.00&lt;sup&gt;n&lt;/sup&gt;</td>
<td>2.67&lt;sup&gt;k&lt;/sup&gt;</td>
</tr>
<tr>
<td>25</td>
<td>0.00&lt;sup&gt;n&lt;/sup&gt;</td>
<td>1.39&lt;sup&gt;m&lt;/sup&gt;</td>
</tr>
<tr>
<td>50</td>
<td>0.00&lt;sup&gt;n&lt;/sup&gt;</td>
<td>2.03&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>75</td>
<td>0.00&lt;sup&gt;n&lt;/sup&gt;</td>
<td>2.28&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>100</td>
<td>0.00&lt;sup&gt;n&lt;/sup&gt;</td>
<td>3.28&lt;sup&gt;j&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>0.00&lt;sup&gt;n&lt;/sup&gt;</td>
<td>2.33&lt;sup&gt;j&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>0.33&lt;sup&gt;j&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>9.29&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Means within a column followed by same letter(s) are not significantly different at 5% LSD test.

Verification of significant differences was done using LSD test at 5% probability level.

RESULTS AND DISCUSSION

Weight loss percentage

The interaction effect of harvesting stage and storage duration on mean weight loss percentage (WLP) of sweet pepper fruits was highly significant (P<0.001); while all other interaction effects were non-significant (P>0.05). At one week of storage, mean WLP of fruits harvested at 0, 25, 50, 75 and 100% colouration stages were 2.67, 1.39, 2.03, 2.28 and 3.28%, respectively; similar trends were observed at other storage times (Table 1). Mean WLP of fruits harvested at full green stage were 0.00, 2.67, 3.61, 4.60 and 6.01 at 0, 1, 2, 3 and 4 weeks of storage, respectively; the same results were apparent at other harvesting stages (Table 1).

The highest and lowest WLP were recorded for combinations of harvested at completely ripened stage and four weeks storage as well as harvested at 25% colouration stage and one week storage under PRS, respectively (Table 1).

Across all storage periods, the WLP of sweet pepper fruits harvested at completely ripened and full green stages were significantly higher than fruits harvested at intermediate stages (Table 1). This is in agreement with the findings of Moneruzzaman et al. (2009) who observed a higher WLP in fruits harvested at early matured stage than intermediate stages. This might be due to poorly developed waxy layer and cuticle on the surface of green pepper fruits as supported by Melaku et al. (2006). The high WLP in completely ripened fruits could be due to changes in permeability of cell membranes, making them more sensitive to the loss of water as confirmed by Antoniali et al. (2007).

Fruit firmness

The main effects of variety, harvesting stage and storage duration on mean firmness of fruits were highly significant (P<0.001); while all other interaction effects were non-significant (P>0.05). The highest fruit firmness of 36.06 N was recorded for variety Telmo-Red whereas the lowest value (30.97N) was recorded for Velez-Yellow variety (Table 2). The mean firmness of fruits harvested at 0, 25, 50, 75 and 100% colouration stages were 38.41, 36.33, 33.60, 31.06 and 28.17 N, respectively. The maximum and minimum firmnesses were recorded at full green and completely ripened harvesting stages, respectively (Table 2). The mean fruit firmness of sweet peppers stored for 0, 1, 2, 3 and 4 weeks under PRS were 35.75, 34.73, 33.35, 32.58 and 31.16 N, respectively. The highest and lowest values were recorded at four weeks and zero week storage periods, respectively (Table 2).

Telmo-Red variety was 14.12% firmer than Velez-Yellow variety (Table 2). This finding is in agreement with results of Lahay et al. (2013) who reported that the value of fruit firmness varied in magnitude between varieties of tomato fruits. The observed variation might be due to genetic or environmental factors as confirmed by Beckles (2012). Ilic et al. (2012) disclosed that the higher pericarp thickness of a variety, the better is the firmness of fruit.

Fruit firmness decreased with increase in harvesting stages (Table 2). The present result is in coherence with the findings of Zhou et al. (2011) who found a decrease in fruit firmness with increasing harvesting stages. The apparent decline in fruit firmness with age might be due to cell wall softening directly influencing the levels of fruit firmness. This is in line with the work of Rao et al. (2011) who found that cell wall softening is due to the activity...
of softening enzymes such as pectin methylesterase.

The mean fruit firmness progressively decreased with increase in storage time (Table 2). This result is consistency with reports of Lahay et al. (2013) who found a reduction in firmness of fruits during prolonged storage periods. This could be due to high respiration rate and weight loss as supported by Cantwell et al. (2009).

### Total soluble solids

The main effects of variety, harvesting stage and storage duration on mean total soluble solids (TSS) were highly significant \((P<0.001)\); while all interaction effects were non-significant \((P>0.05)\). The maximum TSS of 7.22 °Brix was recorded for Telmo-Red variety whereas the lowest (6.56 °Brix) was recorded for Velez-Yellow variety (Table 2). The mean TSS content of fruits harvested at 0, 25, 50, 75 and 100% colouration stages were 5.36, 5.64, 7.02, 7.63 and 8.03 °Brix, respectively. The maximum and minimum TSS contents were recorded at completely ripened and full green harvesting stages, respectively (Table 2). The mean TSS of fruits stored at 0, 25, 50, 75 and 100% colouration stages were 5.36, 6.40, 7.02, 7.63 and 8.03 °Brix, respectively. The maximum and minimum TSS contents were recorded at completely ripened and full green harvesting stages, respectively (Table 2). The mean TSS of fruits stored for 0, 1, 2, 3 and 4 weeks under PRS were 6.48, 6.88, 7.35, 7.07 and 6.66 °Brix, respectively. The highest and lowest TSS values were recorded at two weeks and zero week storage periods, respectively (Table 2).

The maximum TSS content was recorded in Telmo-Red variety which showed 0.66 °Brix higher than Velez-Yellow variety (Table 2). This is in agreement with the results of Bernardo et al. (2008) who reported that the value of TSS varied in magnitude between varieties of sweet pepper fruits. The observed TSS variation between varieties might be due to genetic or environmental factors as confirmed by Beckles (2012).

The level of TSS content progressively increased with increase in harvesting stage (Table 2). The Mean TSS in completely ripened fruits was 2.67 °Brix higher than those harvested at full green stage (Table 2). The TSS content in this study is in line with reports of Antoniali (2007) who found minimum and maximum TSS values in yellow sweet pepper fruits assessed at full green and completely ripened maturity stages, respectively. The increment in TSS might be due to disassociation of some molecules and structural enzymes in soluble compounds, which directly influence the levels of TSS.

TSS content was increased during the first two weeks storage under PRS followed by a decreasing trend with increase in storage duration (Table 2). This result is in agreement with reports of Rao et al. (2011) who found an increase in TSS as fruits were stored for short period followed by a decreasing trend during prolonged storage periods. The increment in TSS for stored fruits was probably due to increase of respiration and metabolic activity. In this regard, Ali et al. (2011) found that the higher respiration rate increases the synthesis and use of
TABLE 3. Interaction effect of variety and harvesting stage on mean titratable acidity of sweet pepper fruits stored under passive refrigeration system.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Titratable acidity (%)</th>
<th>Harvesting stage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Telmo-Red</td>
<td>0.56^c</td>
<td>0.62^d</td>
</tr>
<tr>
<td>Velez-Yellow</td>
<td>0.43^f</td>
<td>0.45^e</td>
</tr>
<tr>
<td>Mean</td>
<td>0.49</td>
<td>0.54</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td>7.58</td>
<td></td>
</tr>
</tbody>
</table>

Means within a column followed by same letter(s) are not significantly different at 5% LSD test.

Postharvest decay percentage

The three-way interaction effect of variety, harvesting stage and storage duration on mean postharvest decay percentage of fruits under PRS was highly significant (P<0.001). At zero and one week storage decay, all fruits of both varieties were free from any postharvest decay across all harvesting stages. At two weeks of storage, mean PDP of Telmo-Red variety harvested at 0, 25, 50, 75 and 100% colouration stages were 1.63, 0.00, 0.20, 0.90 and 2.33%, respectively; similar trends were observed at three and four weeks under passive refrigeration system (Table 4). Postharvest decay percentages of Velez-Yellow variety harvested at 0, 25, 50, 75 and 100% colouration stages were 2.78, 1.16, 1.96, 2.44 and 3.35%, respectively; similar trends were observed at three and four weeks under passive refrigeration system (Table 4).

Starting from two weeks of storage, PDP of both varieties harvested at all maturity stages was increased with increasing storage periods (Table 4). Starting from two weeks of storage, fruits of both varieties harvested at completely ripened and free green stages had significantly higher PDP than the other harvesting stages; however it was significantly lower for Telmo-Red variety (Table 4). The present findings are in conformity with reports of Ciccarese et al. (2013) who found that PDP in fruits harvested at completely ripened stage and stored for longer period of time was always higher than fruits harvesting at intermediate stages and stored for less time. Bayoumi (2008) concluded that the higher PDP in late harvesting stage of fruits was due to higher rate of respiration, more skin permeability for water loss and high susceptibility to decay. Moneruzzaman et al. (2009) also determined that fruit PDP increases when fruits are harvested at early matured stage due to poorly developed fruit cuticular wax layer. The increment in PDP during prolonged period of time could be due to the influence of high respiration rate, fruit senescence and enzymatic degradation of fruits’ cell wall (Ciccarese et al., 2013).

metabolites result in higher TSS due to the higher change from carbohydrates to sugars.

Titratable acidity

The interaction effect of variety and harvesting stage on mean titratable acidity (TA) was highly significant (P<0.001); while all other interaction effects were non-significant (P>0.05). For Telmo-Red variety, mean TA of fruits harvested at 0, 25, 50, 75 and 100% colouration stages were 0.56, 0.62, 0.69, 0.51 and 0.39%, respectively; while for Velez-Yellow variety, TA of fruits harvested at 0, 25, 50, 75 and 100% colouration stages were 0.43, 0.45, 0.51, 0.36 and 0.29%, respectively (Table 3).

TA values of fruits harvested at full green stage were 0.56 and 0.43% for Telmo-Red and Velez-Yellow varieties, respectively; the same results were apparent at other harvesting stages (Table 3). The highest and lowest TA values were recorded at combinations of Telmo-Red variety and harvested at 50% colouration as well as Velez-Yellow variety and harvested at completely ripened stage, respectively (Table 3).

For both varieties, the TA values of fruits harvested at 50 and 25% colouration stages were significantly higher than fruits harvested at other stages. There was an increasing trend in TA value until fruits attained their half ripening stage and thereafter decreased with increasing harvesting stages for both varieties (Table 3).

The results are in coherence with reports of Anthon et al. (2011) who found that TA of tomato fruits was increased with maturity stages and reached the peak at half ripening stage and thereafter started to decrease. The increase in TA value might be due to the presence of pectin methylesterase enzyme activity; while the reduction in TA of fruits harvested after half ripening stage could be due to high respiration rate and reduction in organic acids as supported by Anthon and Barrette (2012).
Table 4. Interaction effect of variety, harvesting stage and storage duration on postharvest decay percentage of sweet pepper fruits stored under passive refrigeration system.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvesting stage (%)</th>
<th>Postharvest decay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>Telmo-Red</td>
<td>0.00† 0.00†</td>
<td>1.63† 4.45‡</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>0.00† 1.39†</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>0.90† 2.07øpq</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>2.33mo 4.77fi</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>1.01 2.91</td>
</tr>
<tr>
<td></td>
<td>Mean 0 0</td>
<td>1.01 2.91</td>
</tr>
<tr>
<td>Velez-Yellow</td>
<td>0.00† 0.00†</td>
<td>2.78kl 5.89</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>1.16bi 2.57m</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>1.96pq 2.87k</td>
</tr>
<tr>
<td></td>
<td>0.00† 0.00†</td>
<td>3.35 6.49</td>
</tr>
<tr>
<td></td>
<td>Mean 0 0</td>
<td>2.34 4.22</td>
</tr>
</tbody>
</table>

LSD (0.05) 0.29
CV (%) 8.95

Means within a column followed by same letter(s) are not significantly different at 5% LSD test.

Table 5. Interaction effect of harvesting stage and storage duration on mean shelf life of sweet pepper fruits stored under passive refrigeration system.

<table>
<thead>
<tr>
<th>Harvesting stage (%)</th>
<th>Shelf life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>0</td>
<td>11.17† 14.00øno</td>
</tr>
<tr>
<td>25</td>
<td>14.00ç 16.17m</td>
</tr>
<tr>
<td>50</td>
<td>13.34b 15.83øm</td>
</tr>
<tr>
<td>75</td>
<td>12.33h 14.52øn</td>
</tr>
<tr>
<td>100</td>
<td>9.67g 13.00øpq</td>
</tr>
<tr>
<td>Mean</td>
<td>12.10</td>
</tr>
</tbody>
</table>

LSD (0.05) 0.99
CV (%) 3.97

Means within a column followed by same letter(s) are not significantly different at 5% LSD test.

Shelf life

The interaction effect of harvesting stage and storage duration on mean overall shelf life (shelf life under PRS plus after being transferred to room temperature) of sweet pepper fruits was highly significant (P<0.001); while all other interaction effects were non-significant (P>0.05). At zero week of storage, mean shelf life of fruits harvested at 0, 25, 50, 75 and 100% colouration were 11.17, 14.00, 19.85, 26.32 and 30.17 days, respectively; the same results were apparent at other harvesting stages (Table 5). The maximum and minimum overall shelf lives were recorded at combinations of harvested at 25% colouration stage and four weeks storage under PRS as well as harvested at completely ripened stage and zero week storage under PRS, respectively (Table 5).

Across all storage periods, the shelf life of fruits harvested at 25 and 50% colourations were significantly higher than fruits harvested at full green and late harvesting stages.
stages (Table 5). The present results are in line with the findings of Dilmacunal et al. (2011) who observed that tomato fruits harvested at breaker stage had a better storability potential under cold storage than the unripe and full red fruits. This could be due to the high weight loss percentage and respiration rate of completely ripened fruits and lack of a well developed fruit cuticular wax layer at full green stage which in turn might have resulted in lower shelf life. Moreover, the increasing trend in overall shelf life of fruits during prolonged storage period might be due to the presence of the new, modern and innovative passive refrigeration system storage equipment. This reality is supported by Shen et al. (2013) who found that extension of shelf life of fresh fruit by slowing down the metabolism and reducing fruit deterioration.

Conclusion

The postharvest quality and shelf life of sweet pepper fruits was affected by varieties, harvesting stage and storage duration. TSS content was increased while fruit firmness decreased with increasing harvesting stages. Weight loss percentage, postharvest decay and overall shelf life were found to increase; whereas fruit firmness declined correspondingly with increasing storage periods. The present results showed that Telmo-Red variety harvested at 25 and 50% harvesting stages and stored under Passive Refrigeration System storage condition could maintain better postharvest quality and extend their shelf life for more than one month.

REFERENCES

Diversity analysis of sugarcane genotypes by microsatellite (SSR) markers

Smiullah1*, Farooq Ahmed Khan1, Aqeel Afzal1, Abdullah1, Ambreen Ijaz2 and Usman Ijaz1

1Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.  
2Department of Bioinformatics and Biotechnology, GC University, Faisalabad, Pakistan.

Accepted 11 September, 2013

Thirty (30) simple sequence repeat (SSR) primer pairs chosen randomly from the SSR primer collection were used to detect polymorphism in 17 sugarcane accessions. A total of 62 DNA fragments were generated by the 30 primers with an average of about 2.14 bands per primer. Bands that a primer yielded in the study ranged from 1 to 4. The genetic distances for SSR data using 17 sugarcane accessions, was constructed based on Nei (1978) and relationships between accessions were portrayed graphically in the form of a dendrogram. The value of genetic similarity ranging from 62.90 to 90.30% was observed among the 17 sugarcane accessions. The highest genetic similarity of 90.03% was seen among genotypes S2003-US118 and S2003-US312. From the present study, it may be concluded that SSRs markers are best tool for investigation of genetic diversity in sugarcane.

Key words: Simple sequence repeat (SSR), polymorphism, genetic diversity.

INTRODUCTION

Sugarcane (Saccharum spp. hybrids) is a genetically complex crop of major economic importance in tropical and sub-tropical countries (Khan et al., 2004). It is mainly used for sugar production but recently gained increased attention because of its employment generation potential and recent emphasis on production of bio-fuels. The importance of sugarcane has increased in recent years because cane is an important industrial raw material for sugar and allied industries producing alcohol, acetic acid, butanol, paper, plywood, industrial enzymes and animal feed (Arenobibia, 1998). Considering the current needs of cane industry it is imperative to breed high sugar producing varieties that also have other desired agronomic traits.

Saccharum is a complex genus characterized by high ploidy levels and composed of at least six distinct species - Saccharum officinarum, Saccharum barberi, Saccharum sinensis, Saccharum spontaneum, Saccharum robustum and Saccharum edule (Daniels and Roach, 1987). Sugar recovery can be increased from current average of 8.32 to 10-11% with the development of improved cane varieties. For development of improved varieties, genotypic studies of sugarcane are required. Described as an allopolyploid, modern cultivated sugar-cane have approximately 80-140 chromosomes with 8-18 copies of a basic set (x = 8 or x = 10 haploid chromosome number) (Ming et al., 2001). Continuous selection for the same traits may narrow genetic diversity to the extent that it may be difficult to predict diversity based on pedigree history alone. With the advent of molecular markers, it is now possible to make direct comparison of genetic diversity at the DNA level without some of the over simplifying assumptions associated with calculating genetic diversity based on pedigree history (McIntyre et al., 2001). Rapid advances in the field of molecular biology and its allied sciences made the use of molecular markers a routine practice providing plant breeders a precise tool in analyzing genetic diversity for plant improvement (Andersen and Lubberstedt, 2003).

The molecular markers are of many types e.g. RFLPs,

*Corresponding author. E-mail: sami_1167pbg@yahoo.com.
TRAPs, RAPDs, SNPs, simple sequence repeats (SSRs) and AFLPs. In the present study, microsatellite or SSR marker was used to analyze genetic diversity of different sugarcane genotypes. Microsatellites or simple sequence repeats (SSRs), are stretches of DNA, consisting of tandemly repeated short units of 1-6 base pairs in length. They are ubiquitous in eukaryotic genomes and can be analyzed through PCR technology. The sequences flanking specific microsatellite loci in a genome are believed to be conserved within a particular species, across species within a genus and rarely even across related genera. Simple sequence repeats (SSR) markers reveal polymorphisms due to variation in the lengths of microsatellites at specific individual loci. Microsatellites are born from regions in which variants of simple repetitive DNA sequence motifs are already over-represented (Tautz et al., 1989). It is now well established that the predominant mutation mechanism in microsatellite tracts is 'slipped-strand mispairing'. This process has been well described by Eisen (1999). When slipped-strand mispairing occurs within a microsatellite array during DNA synthesis, it can result in the gain or loss of one, or more, repeat units depending on whether the newly synthesized DNA chain loops out or the template chain loops out, respectively. The relative propensity for either chain to loop out seems to depend in part on the sequences making up the array, and in part on whether the event occurs on the leading (continuous DNA synthesis) or lagging (discontinuous DNA synthesis) strand. SSR allelic differences are, therefore, the results of variable numbers of repeat units within the microsatellite structure; they are therefore, mutational and co-dominant in nature, thus proving to be very informative. Among the range of DNA-based molecular marker techniques, a promising polymerase chain reaction (PCR)-based technique used extensively for genetic mapping (McIntyre et al., 2001), as well as fingerprinting of sugarcane clones (Piperidis et al., 2000; Pan et al., 2002), is microsatellites or SSRs. SSR genetic markers are the best tool to demonstrate the genetic diversity in sugarcane (Smiallah et al., 2012).

The present study was undertaken to investigate the genetic diversity and establish the relationship between different sugarcane genotypes in Pakistan, using SSR markers. Obtaining accurate estimates of the genetic diversity among germplasm sources may increase the efficiency of plant breeding. Knowledge of genetic diversity and relationships among breeding genome, their polymorphic nature, codominance and materials has a significant impact on crop improvement.

**MATERIALS AND METHODS**

The genetic diversity studies were done as a collaborative research, in Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad and Agriculture Biotechnology Research Institute (ABRI), Ayub Agricultural Research Institute (AARI), Faisalabad during 2010-2012. The plant material used for the study of genetic diversity was comprised of seventeen sugarcane accessions (Table 1). These accessions were collected from the germplasm source in the Sugarcane Section of Ayub Agricultural Research Institute, Faisalabad. The genetic material includes commercial cultivars and elite lines.

**PCR amplification**

Fresh young leaves were collected from the field experiment for isolation of the DNA. Total genomic DNA of the plants was extracted by using modified (CTAB) method (Hoisington et al., 1994; Doyle and Doyle, 1990). DNA concentration was determined, using a Nano Drop spectrophotometer (ND1000). Primer selection was based on previous investigation on SSR analysis, carried out with sugarcane genotypes and somaclones in this laboratory. Primer pairs obtained from Gene link company (USA) were used in PCR reaction for each genotype. For SSR analysis, concentration of genomic DNA, 10 × PCR buffer with (NH₄)₂SO₄, MgCl₂, dNTPs primers and taq DNA polymerase were optimized.

A reaction mixture of 20 μl was used to amplify genomic DNA in a thermal cycler (Eppendorf DNA Thermal Cycler 9600). To confirm that the observed bands were amplified genomic DNA and not the primer artifacts, genomic DNA was omitted from control reaction. A negative control was also run to confirm if the master/reaction mixture is correctly prepared or not. The PCR products were electrophoresed at 90 V, in 2% agarose gel for approximately 2 h, using 0.5 × tris-boric acids EDTA (TBE) buffer, along with a DNA molecular size marker.

The gel contained 0.5 μg/ml ethidium bromide to stain the DNA and photographed under UV light using gel documentation system. Reactions were duplicated to check the consistency of the amplified products. Only easily resolved bright DNA bands were scored as presence (1) and absence of bands (0). Coefficient of similarity among somaclones was calculated according to Nei and Li (1978). Similarity coefficient was utilized to generate a dendrogram by means of unweighted pair.

---

**Table 1. Description of seventeen genotypes used in genetic diversity study.**

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Source of collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPF-247</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>SPF-245</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2003-US-618</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2003-US-628</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2002-US-247</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>HSF-240</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>CPF-237</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>CPF-234</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2003-US-718</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2003-US-778</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2003-US-165</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>S-2003US-312</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>HSF-242</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>CP-77-400</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>CP-72-2086</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>SPF-246</td>
<td>AARI, Faisalabad</td>
</tr>
<tr>
<td>SPF-213</td>
<td>AARI, Faisalabad</td>
</tr>
</tbody>
</table>
Data analysis

The data on bands generated by the 30 primers were selected for analysis of genetic diversity (Table 2). The bands were counted by starting from the top and ending with the bottom of the lanes. All segregating bands that were well resolved and unambiguous were scored for the presence (1) or absence (0) in the 17 genotypes. The data of the primers were used to estimate the dissimilarity on the basis of number of unshared amplified products and a dissimilarity matrix was generated using Nei’s similarity indices (Nei, 1978). In addition, population relationships were inferred using the un-weighted pair group of arithmetic means (UPGMA) clustering method using the Popgen software (version 3.5).

RESULTS AND DISCUSSION

In recent years, the popularity of SSR-based markers has increased considerably. The main reasons which make microsatellites an especially attractive tool for a number of applications are: their high levels of allelic variation and their co-dominant character, which means that they deliver more information per unit assay than any other marker systems, thus reducing costs; microsatellites are assayed using PCR, so only small amounts of tissue are required.

Thirty (30) SSR primer pairs chosen randomly from the SSR primer collection were used to detect polymorphism in 17 sugarcane accessions. The PCR product was observed by running on agarose gel to study polymorphism, most of the primers were polymorphic except five primers which were monomorphic and produced only one fragment per primer (Figure 1). All the primers were found to give reproducible bands. A total of 62 DNA fragments were generated by the 30 primers with an average of about 2.14 bands per primer. Bands that a primer yielded in the study ranged from 1 to 4. Generally, the size and the number of bands produced were dependent upon the nucleotide sequence of the primer pair, size of the primer used and the source of the template DNA. In this study the primer used were of the size ranging from 300-420 bp. Reactions were duplicated form to check the consistency of the amplified products. Only easily resolved bright DNA bands were scored.

Cluster analysis

Pattern of polymorphism by SSRs

About 85.25% polymorphism was estimated as 55 out of 62 fragments were polymorphic with 30 primers used among the 17 sugarcane accessions. The rest of the 7 bands were monomorphic in the 17 accessions. In the present study, the 17 sugarcane accessions appeared to show variability with the 30 primers used. Although none of the primers individually was as informative as to differentiate all the accessions; highly polymorphic profiles were obtained with of the primers SMs35.

(Sugarcane Microsatellite primer no.35) while five primer pairs such as SMs46, SMs47, SMs48 SMs49 and SMs50 were found to be monomorphic. Therefore, it may be concluded from the present results that SSRs can be used for identification of genetic diversity and the relationship between the members of the complex species. Jannoo et al. (2001) studied diversity in 96 sugarcane genotypes with just two primer pairs and reported a high level of heterozygosity. Cordeiro et al. (2001) applied 21 primer sets to five sugarcane genotypes, and among them, 17 pairs were polymorphic, but the level of polymorphism (PIC value) in the cultivars detected by these SSRs was low (0.23). The level of polymorphism indicates that distinction between any two varieties is possible with appropriate SSR primer pair. This supports the use of SSR markers, as an excellent tool, for diversity analysis and loci mapping.

Genetic distances/similarities between the accessions

The genetic distance for SSR data using 17 sugarcane accessions, was constructed based on Nei (1978) and relationships between accessions were portrayed graphically in the form of a dendrogram in Figure 2, the value of genetic similarity ranging from 62.90 to 90.30% was observed among the 17 sugarcane accessions. The lowest genetic distance of 62.90% was seen among genotypes S-2003-US-118 and S-2003-US-312. These two genotypes differed from each other only in 5 bands with 14 different primers. The most dissimilar of all the accessions was S-2003-US-118 and SPF-213 with genetic distance of 90.30%. Genomic SSRs have been shown to produce a greater number of alleles and higher PIC values than those from EST derived SSRs in sugarcane (Pinto et al., 2006).

In several other studies, elite sugarcane (Saccharum hybrids) germplasm showed genetic diversity as well (Selvi et al., 2003; Cordeiro et al., 2003). Selvi et al. (2003) revealed a broad range (0.324-0.8335) of pairwise similarity values when tested on 30 or 40 commercial sugarcane cultivars.

Clustering pattern

The cluster analysis based on similarity values has classified all the sugarcane accession in two of the four major groups (I, II, III and IV). The first major group consisted of two accessions CPF-247 and S-2003-US-165 forming the most distinct cluster I. Second major group was further grouped into IIA, IIB and IIC. Group IIA consisted of three accessions namely SPF-245, S-2003-US-618 and HSF-242. Group IIB consists of four genotypes viz. HSF-240, CP-72-2086, S-2003-US-778 and SPF-213. Group IIC contained two accessions CPF-
<table>
<thead>
<tr>
<th>Primer no.</th>
<th>Band size</th>
<th>Primer sequence (F/R)</th>
<th>Annealing temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMs1</td>
<td>600-2000</td>
<td>GGTGTTGACTCTACTCCCGT</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GGTGTTGACTCTACTCCCGT</td>
<td></td>
</tr>
<tr>
<td>SMs2</td>
<td>550-900</td>
<td>CACCTGCTCCCTTCCTCCTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TGAGCAAAGAAAGAAAGTAGT</td>
<td></td>
</tr>
<tr>
<td>SMs3</td>
<td>400-550</td>
<td>CATCTGCTCCCCCTCCTCTCTCTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GATCTCCTGACCGTCTTCCTCC</td>
<td></td>
</tr>
<tr>
<td>SMs4</td>
<td>400-800</td>
<td>GCTCTGCGGCTTGGTCTCG</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CATCCTCAAGCATCTGT</td>
<td></td>
</tr>
<tr>
<td>SMs5</td>
<td>400-600</td>
<td>GACTCCTGTCACCGTCTCTTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ATACCTCAACGCTCTCCCTCC</td>
<td></td>
</tr>
<tr>
<td>SMs6</td>
<td>400-500</td>
<td>CTAAGCAAGAACACAGAAG</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AGCAACAGAGGAGAGAGACAG</td>
<td></td>
</tr>
<tr>
<td>SMs7</td>
<td>400-500</td>
<td>CATGACTAAGGAGGAAGTAGG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GACGACAGTATAGTAAAGAA</td>
<td></td>
</tr>
<tr>
<td>SMs8</td>
<td>400-550</td>
<td>GAGCCGCAAGGAGGCGAC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CATACAAAGGAGGAGGAGACAG</td>
<td></td>
</tr>
<tr>
<td>SMs9</td>
<td>400-500</td>
<td>CTCTCTTTCTCCTCTCCTATT</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GTCTGCTCTGACTCTCCTGTT</td>
<td></td>
</tr>
<tr>
<td>SMs10</td>
<td>500-700</td>
<td>GCTCTCTTCTTCTTCTCCTG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GTCCTTCTCCTCCTGAGTTG</td>
<td></td>
</tr>
<tr>
<td>SMs11</td>
<td>400-500</td>
<td>ACGACATCGCAAGAAGG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AGGAGAGTATAGTAAAGAA</td>
<td></td>
</tr>
<tr>
<td>SMs12</td>
<td>400 - 600</td>
<td>AAATGCTTTGCACTAAC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AAGGAGATGCTGATGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs13</td>
<td>400 - 500</td>
<td>CCCAGAGGAGAACGAAACT</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GATAATGAGGGAAGCAACTG</td>
<td></td>
</tr>
<tr>
<td>SMs14</td>
<td>400-450</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs15</td>
<td>400-600</td>
<td>GTTCTGAGGGTCTTCTGAGAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CTTGGGTTTTCGGAGTCTCTGT</td>
<td></td>
</tr>
<tr>
<td>SMs16</td>
<td>350-600</td>
<td>CTACACATCTCCATTCACAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTAGAGGTCTGAGTTGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs17</td>
<td>300-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs18</td>
<td>350-500</td>
<td>ATACACATCTCCATTCACAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTAGAGGTCTGAGTTGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs19</td>
<td>400-600</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs20</td>
<td>300-400</td>
<td>CTACACATCTCCATTCACAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTAGAGGTCTGAGTTGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs21</td>
<td>350-600</td>
<td>CTACACATCTCCATTCACAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTAGAGGTCTGAGTTGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs22</td>
<td>400-450</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs23</td>
<td>400-500</td>
<td>CTACACATCTCCATTCACAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTAGAGGTCTGAGTTGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs24</td>
<td>350-600</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs25</td>
<td>500-600</td>
<td>CTACACATCTCCATTCACAG</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTAGAGGTCTGAGTTGGAAGA</td>
<td></td>
</tr>
<tr>
<td>SMs26</td>
<td>450-600</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs27</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs28</td>
<td>500-800</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs29</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs30</td>
<td>450-600</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs31</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs32</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs33</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs34</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs35</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs36</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs37</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs38</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs39</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs40</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs41</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs42</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs43</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs44</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs45</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs46</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs47</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs48</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs49</td>
<td>500-700</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
<tr>
<td>SMs50</td>
<td>400-500</td>
<td>GGTCTCCTCCTACTCGTC</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GAGGTCCTTTTGTGAGAGTC</td>
<td></td>
</tr>
</tbody>
</table>
Figure 1. Result of electrophoresis of SSR product of 17 genotypes using sugarcane microsatellite primer no.18.

Figure 2. Dendrogram of 17 sugarcane accessions developed from SSRs data using unweighted pair group of arithmetic means (UPGMA) based on Nei’s (1978) genetic distance.

Conclusions

The analysis of variations in SSR fragments provides an effective tool for examining diversity to improve plant breeding strategies. Identifying useful SSRs is critical but in sugarcane this can be a lengthy and difficult process due to their abundance and the complexity of the sugarcane genome. Less information is available on the genetic diversity within and between Saccharum cultivars which has been based mainly on morphological characteristic. Thus, it can be concluded that estimates of genetic similarity based on molecular markers may provide more accurate information to plant breeder. This data will support the exploitation of sugarcane germplasm on molecular basis. SSR markers used in the study may also be used by researcher for genetic mapping and gene tagging in sugarcane. Locus mapping ability of these SSR markers will provide more information than those available through diversity. These markers may be used for construction of genetic map in sugarcane. Future breeding efforts involving crosses between and within the groups identified in this study may provide useful strategies for combining beneficial genes and alleles in new sugarcane varieties while maintaining genetic diversity.

REFERENCES


UPCOMING CONFERENCES

International Conference on Agriculture and Biotechnology, Kuala Lumpur, Malaysia

Exploiting Bacteriophages for Bioscience, Biotechnology and Medicine, London, UK

2014 - Exploiting bacteriophages for bioscience, biotechnology and medicine (the 5th in a biennial series)

Thursday, 23 January 2014 09:00 - 17:00
Conferences and Advert

**December 2013**
International Conference on Agriculture and Biotechnology, Kuala Lumpur, Malaysia

**January 2014**

Exploiting Bacteriophages for Bioscience, Biotechnology and Medicine, London, UK

National Conference on Frontiers in Biotechnology and Bioinformatics (NCFIBB2014), Navi Mumbai, India
Related Journals Published by Academic Journals

- African Journal of Biotechnology
- Journal of Cell and Animal Biology
- International Journal of Genetics and Molecular Biology
- Biotechnology and Molecular Biology Reviews
- African Journal of Microbiology Research
- African Journal of Biochemistry Research
- African Journal of Environmental Science and Technology
- African Journal of Food Science
- African Journal of Plant Science
- Journal of Ecology and The Natural Environment
- Journal of Entomology and Nematology
- Journal of Bacteriology Research
- Journal of Bioinformatics and Sequence Analysis
- Journal of General and Molecular Virolgy
- International Journal of Biodiversity and Conservation
- Journal of Biophysics and Structural Biology
- Journal of Evolutionary Biology Research
- Journal of Yeast and Fungal Research
- International Journal of Plant Physiology and Biochemistry
- Journal of Brewing and Distilling
- Journal of Computational Biology and Bioinformatics Research
- Journal of Developmental Biology and Tissue Engineering
- Journal of Microbiology and Antimicrobials