Journal of Basic and Applied Scientific Research (JBASR)



An International Peer-reviewed journal

Number of issues per year: 12 ISSN: 2090-4304 (Print) ISSN: 2090-424x (Online)

Volume 8, Issue 6, October 2018



J. Basic Appl. Sci. Res., Vol.8 No. 6: pp. 1-10, Year 2018

Journal of Basic Monthly Publicatio	and Applied Scientific Res	search (JBASR)			
The second se	Number of issues per year ISSN: 2090-4304 (Print) ISSN: 2090-424x (Online	: 12 e)			
Journal of Transcard Applied	Journal of Basic and Applie international scientific journal of well as review articles in the a	d Scientific Research (JBASR) is dedicated for rapid publication of hi II areas of basic and applied science	a peer reviewed, open access gh quality original research articles as es.		
😸 Technologian 👬	Journal of Basic and Appli original and significant researc	ed Scientific Research (JBASR)) is devoted to the rapid publication of		
	Accounts	Energy	Nuclear Engineering		
	Agricultural Sciences	Engineering, All Fields	Oceanography		
0	Applied Biology	Entomology	Oncology		
Scope	Biochemistry	Environment	Parasitology		
	Biological Sciences	Evolution	Petroleum & Gas		
	Biophysics	Fisheries	Pharmacology		
	Business and Economics	Food & Food Technology	Physics		
	Cell Biology	Genetics	Physiology		
	Chemical Engineering	Genomics	Plant Biology		
	Chemical Engineering	Geology	Population Biology		
	Chemistry	Immunology	Religious Studies		
	Civil Engineering	Infectious Diseases	Robotics		
	Civil Engineering	Law	Signal Transduction		
	Commerce	Marine Sciences	Social Sciences		
	Communication & IT	Marine Technology	Solid State Technology		
	Computer Science	Mathematics & Statistics	Space Science		
	Construction	Medical Technology	Textile Industry & Fabrics		
	Dentistry	Medicine	Toxicology		
	Developmental Biology	Microbiology	Transportation		
	Ecology	Nanotechnology	Veterinary Science		
	Endocrinology	Neuroscience	Zoology		

Editorial Board

Editor -in-Chief

William Ebomoyi Ph.D., Professor, Department of Health Studies, College of Health Sciences, Chicago State University, USA. E-mail: editor@textroad.com

Associate Editors

Prof. Dr. Sarwoko Mangkoedihardjo

Professor, Professional Engineer of Indonesian Society of Sanitary and Environmental Engineers, Indonesia

Saeid Chekani Azar

PhD of Veterinary Physiology; Faculty of Veterinary, Department of Physiology, Ataturk University, Erzurum 25010, **Turkey**.

Prof. Dr. Ashraf Latif Tadross

Head of Astronomy Department, Professor of Star Clusters and Galactic Structure, National Research Institute of Astronomy & Geophysics (NRIAG), 11421 Helwan, Cairo, **Egypt**.

Prof. Dr. Mario Bernardo-Filho

Full Professor, Universidade do Estado do Rio de Janeiro, Head, Laboratório de Radiofarmácia Experimental, Brazil.

Dr. Mounir M. Salem-Bekhet

Associate Professor of Microbiology, Department of Pharmaceutics, King Saud University, KSA.

Dr. Sandra Pacios Pujado

University of Pennsylvania, Philadelphia, PA, USA.

Vishal Patil, PhD

Materials Research Laboratory, University of California, Santa Barbara, CA, USA.

Dr. YUBAO CUI

Associate Professor, Department of Laboratory Medicine, Yancheng Health Vocational & Technical College, Jiangsu Province, P. R. China

Raja S Payyavula

Research Associate, Bio Science Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA.

Dr. Zhihong Song

The Ames Laboratory of US DOE, 2238 MBB Iowa State University, IA 54411 USA.

Prof. Dr. Nasser Fegh-hi Farahmand

Associate professor, Department of Industrial Management, Tabriz Branch, Islamic Azad University, Tabriz, Iran

Prof. Dr. Valdenir José Belinelo

Department of Health Sciences and Postgraduate Program in Tropical Agriculture, Federal University of Espirito Santo (UFES, São Mateus, ES, **Brazil**

Dr. Chandrasekar Raman

Research Associate, Department of Biochemistry & Molecular Biophysics, Biotechnology Core Facility, 238, Burt Hall, Kansas State University, Manhattan 66506, KS, USA.

Mr. Jiban Shrestha

Scientist (Plant Breeding and Genetics), Nepal Agricultural Research Council, National Maize Research Program, Rampur, Chitwan, Nepal

Dr. Nadeem Javaid

Ph.D. (University of Paris-Est, France), Assistant Professor, Center for Advanced Studies in Telecommunications (CAST), COMSATS Institute of IT, Islamabad, **Pakistan**

Dr. Syamkumar Siv Pillai

Program Manager-National Clean Plant Network - Fruit Trees, Washington State University, USA

Dr. Hala Ahmed Hafez Kandil

Professor Assistant, National Research Centre, Plant Nutrition Department. Dokki, Giza, Cairo, Egypt

Prof. Dr. Aziza Sharaby

Pests and Plant Protection Department, National Research Center, Cairo, Egypt

Prof. Dr. Sanaa T. El-Sayed

Ex Head of Biochemistry Department, Professor of Biochemistry, Genetic Engineering &Biotechnology Division, National Research Centre, **Egypt**

Dr. Pratap V. Naikwade

M.Sc., Ph.D. Head, Department. of Botany, ASP College, Devrukh. Maharashtra, India.

Shadia M. Abdel-Aziz

Microbial Chemistry, National Research Center, Egypt

Dr. Tarig Osman Khider

Associate Professor, University of Bahri-Sudan, College of Applied and Industrial Sciences, Department of Pulp and Paper Technology, **Sudan**

Dr. Hayman Z. Metwally

Associate Professor of Space Science cairo University **Egypt** and Vice Dean of Quality Assurance and Development Hayel University **KSA**.

Dr. Nawfal Jebbor

Department of Physics, Moulay Ismail University, Meknes, Morocco.

Dr. Eng.Ahmed Kadhim Hussein

Assistant Professor, Department of Mechanical Engineering, College of Engineering, University of Babylon, **Republic of Iraq.**

Prof. Dr. Abd El Fady Beshara Morcos

Ass. Prof. of Relativistic Astrophysics and Cosmology, National Research In stitute of Astronomy and Geophysics, Egypt.

Zohre Bahrami

Shahid Beheshti University of Medical Sciences, Tehran, Iran. Researcher and Methodology Adviser.

Dr. Ayhan Kapusuzoglu

Department of Banking and Finance, Yildirim Beyazit University, Turkey.

Dr. Charalambos Tsekeris

Department of Psychology, Panteion University of Social and Political Sciences, Athens, Greece.

Dr. Mahdi Zowghi

Industrial and System Engineering, Management and Soft Computing, London Business and engineering School, **United Kingdom.**

Dr. Tomislav Jurendic

Bioquanta Ltd. for Research and Development, Koprivnica, Croatia

Dr. Hanna Bolibok-Bragoszewska

Warsaw University of Life Sciences, Poland.

Prof. Md. Amin Uddin Mridha

Ph.D. DIC (London), Plant Production Department, King Saud University, P.O.Box 2460, Riyadh 11451, **Kingdom of Saudi Arabia**

Dr. Alaa Abdelwahed Abdelbary

Prof. of Computational and Applied Mathematics, Arab Academy for Science and Technology & Maritime Transport, Egypt.

Dr. N R Birasal

Associate Professor, Zoology Department, KLE Society's G H College, HAVERI - 581 110, Karnataka state, India.

Dr. Nawab Ali Khan

Professor of Human Resource Management, College of Business Administration, Salman Bin Abdulaziz University, Post Box:165, Al Kharj - 11942 Kingdom of Saudi Arabia

Editors

Dr. Mukesh Kumar Meena

Assistant Professor (Crop Physiology), Department of Crop Physiology, University of Agricultural Sciences, Raichur-584104, Karnataka , India

Prof. Dr. Tarek Ahmed Shokeir

Professor and Consultant, Department of Obstetrics & Gynaecology, Fertility Care Unit, Mansoura University Teaching Hospitals, Mansoura Faculty of Medicine, **Egypt**

Leila Falahati

Department of Resource Management and Consumer Studies, Faculty of Human Ecology, University Putra Malaysia.

Dr. Muhammad Ismail Mohmand

Tutor/Administrator in the Excellence Training Den College in Newcastle, United Kingdom

Noorbakhsh Hooti

Associate Professor in Dramatic Literature, Razi University, Faculty of Arts, English Department, Kermanshah, Iran

Dr. Ali Elnaeim Musa

University of Bahri, Sudan College of Applied and Industrial Sciences, Sudan

Prof. Dr. Magda M.A. Sabbour

Professor, Department of Pests and Plant Protection- National Research Centre, Cairo, Egypt.

Dr. Vahid Majazi Dalfard

Department of logistics and operation management, University of Vienna, Vienna, Austria

Dr. Basharia Abd Rub Alrasoul Abd Allah Yousef

Deputy Dean at Faculty of Engineering, University of Bahri, Khartoum, Sudan

Nasser Mousavi

Islamic Azad University, Bilesavar Branch, Iran.

Dr. Jinu John

Associate Professor (Biotechnology), Jinu Bhavan, Chepra (P. O), Kottarakara, Kollam (Dist.), Kerala - 691520; India.

Seyyed Mousa Hosseini

Head of Young Researchers Club, Islamic Azad University (Sama Organization), Mazandaranand, Gilan province, Iran.

Dr. Sunil Kumar

Assistant Professor, Department of Mathematics, National Institute of Technology, Jamshedpur, 831014, Jharkhand, India

Dr. Seyed Hossein Hosseini Nazhad

Department of Computer Engineering, Islamic Azad University, Iran

Zairi Ismael Rizman

Senior Lecturer, Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) (Terengganu) Malaysia

Muhammad Attique Khan Shahid,

Associate Professor of Physics, Department of Physics, GC University, Faisalabad. **Pakistan.** PNRA certified Health Physicist, RPO, RSO Atomic and Nuclear Physics Lab

Mohsen Shafiei Nikabadi(PhD.)

Assistant Professor, Faculty of Economics and Management, Industrial Management Department, Semnan University, Semnan, Iran.

Dr.Vuda Sreenivasarao

Department of Computer and Information Technology, Defence University College, Deberzeit, Ethiopia

Dr. Mohdammed Israil

Post Doctoral Fellow, University Sains Malaysia, Pulau Penang, Malaysia.

Dr. S. Ravichandran

Assistant Professor, Department of Physics, Sathyabama University, India

Dr. Sukumar Senthil Kumar

School of Mathematical Sciences, Universiti Sains Malaysia, Malaysia.

Seifedine Kadry

American University of the Middle East, Kuwait.

Dr. Datta Asaram Dhale

Assistant Professor, Post Graduate Department of Botany, Ghogrey Science College, Dhule - Maharashtra State, India.

Dr. Ho Soon Min

Senior Lecturer, Faculty of Applied Sciences, INTI International University, Persiaran Perdana BBN, Putra Nilai, Negeri Sembilan, Malaysia.

Dr. Ezzat Molouk Kenawy

Economic Department, Faculty of Commerce, Kafr El-Sheikh University, Egypt.

Dr. Farooq Ahmad Gujar

Centre for Advanced Studies in Pure and Applied Mathematics, Bahauddin Zakariya University, Multan, 60800, **Pakistan.** & Head of Institution / Principal / Associate Professor of Mathematics.

Alireza Karbalaei

Assistant Professor, Department of English, Qeshm International Branch & Shariaty College, Iran.

Dr. Seshadri Sekhar. Tirumala

Principal, Chirala Engineering College, India.

Sayed Roholla Mousavi,

Department of Agriculture, Payame Noor University, Tehran, Iran.

Dr. Tarek Y. El-Hariri

Associated Professor, Egyptian Petroleum Research Institute, Exploration Department, Egypt.

Dr Mamode Khan Naushad

Department of Economics and Statistics, Faculty of social studies and humanities, University of Mauritius, Mauritius.

Dhahri Amel

Research professor, Research Unit: Materials, Energy and Renewable Energies (MEER)-Science Faculty of Gafsa, **Tunisia.**

Dr. Muhammad Waqas Anwar

COMSATS Institute of Information Technology, University Road, 22060, Abbottabad, Pakistan.

Prof. Dr. Abdul-Kareem J.Al-Bermany

Advance Polymer Laboratory, Physics Department/College of Science/Babylon University, Iraq.

Dr. Bensafi Abd-El-Hamid

Assistant Professor, Dept. of Chemistry, Faculty of Sciences, Abou Bekr Belkaid University of Tlemcen, Algeria.

Dr. Vikas Anand Saharan

Assistant Professor & Head, Department of Pharmaceutics, Institute of Pharmaceutical Sciences & Drug Research, Seth GL Bihani SD College of Technical Education, **India**.

Dr. Syed Zulfiqar Ali Shah

Chairman Higher Studies and Research, Faculty of Management Sciences, International Islamic University Islamabad, **Pakistan.**

Saima Anis Mustafa

Assistant Professor in COMSATS Institute of Information Technology, University Road, Abbottabad, Pakistan

Dr. Nagasamy Venkatesh

Assistant Professor, Dept. of Pharmaceutics, JSS College of Pharmacy, Tamil Nadu, India.

Mirza Hasanuzzaman

Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Dr.K.V.L.N.ACHARYULU

Faculty of Science, Department of Mathematics, Bapatla Engineering college, Bapatla, India.

Maryam Ahmadian

Post Doctoral Fellow, Department of Social and Development Sciences, Faculty of Human Ecology, Universiti Putra, UPM Serdang, Selangor, Malaysia.

Dr. Mohammad Abul Hossain

Associate Professor, Department of Chemistry, University of Dhaka, Bangladesh.

Abdel Baset Hasoneh,

PhD, Associate professor of Marketing, Head of marketing Department Al Isra University - Amman, Jordan

Dr. Muhammad Akram

Faculty of Agriculture, Department of Eastern Medicine and Surgery, University of Poonch, Rawalakot, Azad Jamu and Kashmir, **Pakistan**.

Dr. Anshoo Agarwal

RAK Medical College and Health Sciences University, P.O.Box:13268, RAK, UAE, United Arab Emirates

Dr. Aamir Shhazad

Assistant Professor, Department of Physics, GC University, Faisalabad

Dr.(Mrs.) Sunanda Sharma

B.V.Sc & A.H., M.V.Sc., Ph.D. Department of Veterinary Gynecology and Obstetrics, College of Veterinary & Animal Science, Rajasthan University of Veterinary & Animal Sciences, Bikaner, **India**.

Muhamad Fazil bin Ahmad

Asst. Prof. Universiti Sultan Zainal Abidin, Terengganu, Malaysia.

Shaukat Amer

CPA, Assistant Professor, Department of Management Sciences, COMSATS Institute of Information Technology, Attock, **Pakistan.**

Mohammad Hassan Boostani

Education Organization of Fars Province & Young Researchers and Elites Club, Zarghan Branch, Islamic Azad University, Zarghan, Iran

Naveed Ahmed

Assistant Professor, Department of business administration, Indus International Institute, 2-Km, Jampur Road, Dera Ghazi Khan, Pakistan

Rab Nawaz Lodhi

PhD (ABD), Management Sciences (Bahria University Islamabad), Lecturer: Department of Management Sciences, COMSATS Institute of Information Technology, Sahiwal, Pakistan. International Licensed Trainer - NVivo Qualitative Research: QSR International Limited Australia

Dr. Majid Sharifi Rad

Department of Range and Watershed Management, Faculty of Natural Resources, University of Zabol

Dr. Muhammad Naeem

LECTURER, Department of Information Technology, Hazara University, Mansehra.

Dr. Sohrab Mirsaeidi

Centre of Electrical Energy Systems (CEES), Faculty of Electrical Engineering (FKE), Universiti Teknologi Malaysia (UTM), 81310 Skudai, Johor, Malaysia

Dr. Muhammad Majid Gulzar

Faculty of Engineering, University of Central Punjab, Lahore, Pakistan

Farhan Altaee

Ministry of Science and Technology, Iraq-Baghdad

Dr. Hafiz Abdul Wahab

Assistant Professor of Mathematics, Department of Mathematics, Hazara University Mansehra Pakistan.

Dr. Rohit Bansal

Assistant Professor, Department of Management Studies, Vaish College of Engineering, Rohtak (Haryana), India

Dr. Muhammad Akram

Faculty of Agriculture, Department of Eastern Medicine and Surgery, University of Poonch, Rawalakot, Azad Jamu and Kashmir, **Pakistan**.

Dr. Meena M.K.

M.Sc.(Agri.), Ph.D., Assistant Professor, Department of Crop Physiology, University of Agricultural Sciences, Raichur-584104,Karnataka, **India**.

Table of Contents, October 2018

Ousmane Seyni Diakité, Mamadou Aissata, Sissoko Aliou, Sanogo Sekouba, Mamoutou Kouressy, Vaksmann Michel, Daniel K. Dzidzienyo, Danquah Eric, Tongoona Pangirayi, Karim Traoré, Niaba Teme

Brown midrib 6 and *12* Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility

J. Basic Appl. Sci. Res. 2018 8(6): 1-10. [Abstract] [Full-Text PDF] [Full-Text XML]



J. Basic. Appl. Sci. Res., 8(6)1-10, 2018

© 2018, TextRoad Publication

ISSN 2090-4304 Journal of Basic and Applied Scientific Research www.textroad.com

Brown midrib 6 and 12 Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility

Ousmane Seyni Diakité¹, Mamadou Aissata¹, Sissoko Aliou², Sanogo Sekouba², Mamoutou Kouressy², Vaksmann Michel ^{3,4}, Daniel K. Dzidzienyo⁵, Danquah Eric⁵, Tongoona Pangirayi⁵, Karim Traoré⁶, Niaba Teme²

¹Institut National de la Recherche Agronomique du Niger (INRAN) Niger. BP 429 Niamey
 ²Institut d'Economie Rurale (IER) BP 258 Rue Mohamed V. Bamako Mali.
 ³ CIRAD, UMR AGAP, BP 1813, Bamako, Mali
 ⁴ AGAP, Univ. Montpellier, CIRAD, INRA, Montpellier SupAgro, Montpellier, France.

⁵ University of Ghana, West Africa Centre for Crop Improvement (WACCI). PMB LG 30, Legon Accra Ghana ⁶ Africa Rice Center, St. Louis, BP 96, Sénégal.

> Received: August 26, 2018 Accepted: October 12, 2018

ABSTRACT

Introgression of *bmr* genes from less adapted donor parent to well adapted high yielding biomass varieties with poor nutritional value is very important for sustainable cattle feeding during pasture scare time in the Sahel. The main objective of this work was to introgress *bmr6* and *bmr12* genes in Nigerien and Malian sorghum varieties background for dual purpose grain and biomass potential. The plant material was composed of two improved sorghum varieties (Sepon82 and Kalla Kéné) and El mota a farmer preferred variety as recurrent parents. *bmr* donor parents were redlan *bmr6*, Tx630 *bmr12* and Wheatland *bmr12*. The hand emasculation technique was used to introgress *bmr* genes in recurrent parents to produce F3 and BC1F3 populations at Sotuba research Station in Mali from January 2016 to June 2017. Anthocyanin pigment and heterosis effects were key phenotypic traits to identify F1 and BC1F1 plants during the population development. Anthocyanin allowed the identification of F1 plants in a cross involving anthocyanin (purple plant) and tan plants, while for both tan plants cross, heterosis effect was major key to discriminate F1 from parental lines and *bmr* segregation ratios of *bmr* plants in F2 and BC1F2 showed a good fit of a single recessive gene (3:1). *bmr 6* and *12* genes were successfully transferred to three recurrent parents varieties which are at F4 and BC1F3 generation for grain and biomass yields potential tests in Niger during the 2017 cropping season. **KEYWORDS:** *brown midrib* genes, phenotypic marker, segregating populations.

INTRODUCTION

The brown midrid (bmr) trait is a phenotypic marker linked to a genetic mutation. The *bmr* plant type has been identified in maize, sorghum and millet. [1] reported that *bmr* mutants were first discovered in maize, with a total of four genes and described each gene segregating as a simple Mendelian recessive character. In sorghum, [2] claimed that the *bmr* abbreviation was adopted to distinguish it from *bm*, already in use for the sorghum bloomless mutants.

[3] produced 19 *bmr* sorghum mutants by chemically treating seed from two grain sorghum lines. These mutants were numbered *bmr* 1 to *bmr* 19. [3] suggested that the *bmr*-6, *bmr*-12, and *bmr*-18 should be selected for further evaluation. However, the *bmr*-6 and *bmr*-12 genotypes are more prevalent than the *bmr*-18 [4].

[5] reported four allelic groups (bmr19, bmr2, bmr6 and bmr12) of which the latter mentioned here are involved in improving forage quality. [6] stated that mutations in 4-coumarate: coenzyme a ligase (4CL), cinnamyl alcohol dehydrogenase (CAD2) and caffeic O-methyltransferase (COMT) genes contribute to the phenotype of bmr2, bmr6 and bmr12 groups respectively. [7] asserted that the bmr19 appears to be of limited value for forage and bioenergy applications and is not publicly available. [8] demonstrated that the bmr phenotype is the result of a recessive mutation in the lignin biosynthesis pathway. While for ([9]; [10], the effect of bmr mutations on forage quality varies depending on the genetic background of recipient in which the mutation is introduced. Moreover, [11] emphasized on the importance of identifying a suitable genetic background to allow an optimal impact of the mutation.

Corresponding Author: Ousmane Seyni Diakité, Institut National de la Recherche Agronomique du Niger (INRAN) Niger. BP 429 Niamey. E-mail: dseyni@wacci.ug.edu.gh Citation: Ousmane Seyni Diakité, Mamadou Aissata, Sissoko Aliou, Sanogo Sekouba, Mamoutou Kouressy, Vaksmann Michel, Daniel K. Dzidzienyo, Danquah Eric, Tongoona Pangirayi, Karim Traoré, Niaba Teme, 2018, *Brown midrib 6* and *12* Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility; Journal of Basic and Applied Scientific Research, 8(6)1-10.

The *bmr* plants exhibit a reddish brown pigmentation (Photo 1) on its leaf midrib and stalk pith in sorghum associated with lignified tissues since the plants have about five expanded leaves [12]. [13] suggested that *bmr* plants have lignin which is less polymerized and contains less phenolic monomers that can affect digestion. [14] showed that the *bmr* mutant of sorghum have significantly lower levels of lignin content and estimated around 51% less in their stems and 25% less in their leaves; furthermore, *bmr* sorghum silage has 17% less lignin than regular sorghum silage making it more digestible. This property makes *bmr* stovers very attractive for cattle feeding in many countries to improve milk and meat production.

In South Saharan African (SSA) countries particularly in the Sahel region, cereal stovers constitute an important source of feed for livestock during feed scarcity time. Unfortunately, stover from cereals is often of low nutritional quality. [15] affirmed that the potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritive value are employed.

In Niger and Mali research to improve sorghum stover feed value in recent years often emphasized postharvest treatment of crop residues ammonization. This method involves a good control of the technique; additionally, it can also be expensive due to the cost of fertilizers. On the other hand, stay green trait has been incorporated into new lines to enhance cereal stovers quality after harvest. Adding *bmr* trait to local cultivars and newly developed lines will be more sustainable and will bring a significant impact on livestock productivity in these two countries.

To date no studies have been reported on the *bmr* sorghum introgression in local cultivars in Niger and in Mali. The main objectives of this population breeding were to introgress *bmr6* and *bmr12* genes in two Nigerien and one Malian sorghum varieties using phenotypic markers and to validate a dominant Mendelian segregation ratio using χ^2 .

Biology and methods of introgressing a new trait in sorghum

Sorghum has a perfect-flower and is a self-pollinated crop. Its level of outcrossing is contingent on the specific genotype being grown and the environmental conditions encountered prior to and during anthesis [16]. [17] estimated the outcrossing from 1 to 10% and can also reach 30-60% depending to the panicle compactness, while [18] claimed sorghum outcrossing is established from none to 30%.

Sorghum flowering starts few days after panicle exsertion from top to bottom. Based on the flowering habits, sorghum breeders have developed several methods of hybridization and outcrossing elimination (Table 2). Indeed, fertile line panicles' early selfing ensure pure line maintenance whereas several crossing methods were established for segregating populations' development. [16] reported four different methods of crosses:

Hand emasculation (HE)

Panicle chosen for HE is prepared 1-2 days before emasculation. Flowers are emasculated the day before anthesis. Such florets occur below and within about 3 cm of opened florets in a sorghum panicle. All open spikelets are removed with scissors. In addition, all florets except those that are to be emasculated are removed, leaving only the florets that are expected to open the next day. Three anthers are coaxed out of the enclosing lemma and palea by inserting a sharpened pencil or similar pointed instrument such as forceps. Care must be taken not to break the anthers, and if the anther is breached, that flower should be removed and instruments rinsed to avoid contaminating the next floret. Every anther must be removed before the set of florets is completely emasculated [18].

Genetic male sterility: GMS

[19] reported that a series of nuclear recessive male sterility genes, designated as ms1 through ms7, have been characterized in sorghum. These mutations, in the recessive condition result in a male-sterile plant that can be used for hybridization. For [20], the most commonly used is the ms3 due to its stable expression over different environments. These mutations in the recessive condition result in a male-sterile plant that can be used for hybridization.

Cytoplasmic male sterility: CMS

CMS occurs in sorghum. The CMS system was identified and characterized by [21]. There are many different CMS systems, each caused by a different mutation in the cytoplasm and each is complemented by different nuclear restoration loci. [18] reported that for most CMS systems, the interaction of cytoplasmic and nuclear genes defines whether all specific lines are fertile or sterile. The CMS system (Table 1) is widely used in sorghum hybrid seeds production and the following designations were conventionally adopted: A-line=Male sterile line; B-line=Male fertile and an A sterility maintainer line; R-line=Male fertile and is A-line fertility Restorer line. The most commonly used CMS system is the A1 system. In the CMS system, line that has [A] cytoplasm must have a dominant allele

J. Basic. Appl. Sci. Res., 8(6)1-10, 2018

present in the nuclear genome to restore male fertility. If the line lacks the dominant allele for fertility restoration, the plant will be male sterile. Table1 contains information on genotypes and their corresponding phenotypes types in sorghum hybrid seeds production.

Table 1. The Civis system in sorghum								
Line	Cytoplasm	Genotype	Phenotype					
A-line	[A]	rfrf	Male sterile					
B-line	[N]	rfrf	Male fertile					
R-line	[A] or [N]	RF RF	Male fertile					
Hybrid	[A]	RF rf	Male fertile					
Source: [20].								

Table 1. The CMS system in conchum

Hot-water emasculation

This method of emasculation was developed by [22]. In practice, open florets of the selected panicle are removed and the entire panicle is enclosed in a waterproof sleeve of rubber or plastic tied securely around the peduncle. The panicle is immersed in water heated to 42-48°C for 10 min. This treatment kills the majority of the pollen grains but does not damage the ovary [18]. The panicle is allowed to dry and then covered with a paper bag. Pollen from the selected male parent is dusted onto the sterilized panicle 3-4 days after the hot water treatment [18].

Anther dehiscence control by use of humidity

This method was developed by [23] to control anther dehiscence using the humidity created from covering the panicle with a plastic bag prior to flowering. This method, is also known as plastic bag emasculation and/or poured crossing. It allows a breeder to make large numbers of crosses in a short amount of time. This emasculation method is described by [18] as follow: plants selected for use as females in poured crosses have flowered approximately 2.5-5 cm from the panicle apex. The portions of the panicle that have flowered are removed. The bottom florets in the panicle are also removed, so that 3-5 cm of the panicle remains. This panicle is covered with a plastic bag and tied firmly on its peduncle while covering it with a pollinating bag to shade and to reduce the temperature of the panicle under the plastic bag. The bag remains on the plant for 2-3 days during which the panicle completes anthesis. These bags create a highly humid atmosphere in which the moisture content inhibits anther dehiscence. Because all of the anthers are not removed, a certain level of self-pollination will occur in seed from a poured cross.

Table 2: advantages and disadvantages of emasculation techniques in sorghum for diversity development.

Method	Advantages	Disadvantages
Hand emasculation-HE	Require simple tools [17].	Varieties differ in ease of emasculation [17]. Produce small quantities of seeds [16]. Takes special skill and time consuming [16].
Genetic male sterility-GMS	Simple and breeders can make a large number of crosses in a short amount of time [18].	Cannot be used for commercial hybrids seeds production. Request the prior development of ms3 lines.
Cytoplasmic male sterility- CSM	Possibility of commercial hybrid seeds production [17]. Simple and breeders can make a large number of crosses in a short amount of time [18].	Request the prior development of A and B lines. Female parent limited to A lines and thus reduction of available cytoplasms
Hot-water emasculation	Simple to use in green house [18].	High level of seedlings from self- fertilization in the nurseries.
Anther dehiscence control with humidity	Simple and breeders can make a large number of crosses in a short amount of time [18].	A certain level of self-pollination can occur in seed from a poured cross [18]. In most cases, the proportion of progeny that are F1 hybrids will vary based on the specific genotype used as a female parent, the fecundity of the pollen parent, and the environmental conditions during the process [18].

Sources: [17]; [18]; [16]

MATERIAL AND METHODOLOGY

Material

The plant material was composed of six Caudatum types (Table 3): Sepon82 (Niger); Kalla Kéné from the Malian national catalogue and El mota (Nigerien farmer variety) as recurrent parents (RP). Three bmr donor parents (DP), originated from Purdue University, Indianapolis (USA), composed of Redlan bmr6, Wheatland bmr12, and Tx630 bmr12, were used [24].

Citation: Ousmane Seyni Diakité, Mamadou Aissata, Sissoko Aliou, Sanogo Sekouba, Mamoutou Kouressy, Vaksmann Michel, Daniel K. Dzidzienyo, Danquah Eric, Tongoona Pangirayi, Karim Traoré, Niaba Teme, 2018, Brown midrib 6 and 12 Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility; Journal of Basic and Applied Scientific Research, 8(6)1-10.

The RPs (Sepon82 and El mota) are largely grown by Nigerien farmers for their stover and grain yield potential. RPs stover yield potential data were collected from sorghum breeders of Institut National de la Recherche Agronomique du Niger (INRAN) and farmers during the 2016 Participatory Rural Appraisal (PRA) survey in Niger. Selected RPs were therefore very good candidates for the dual purpose sorghum breeding. Kalla Kéné is a stay green late maturing improved variety from Malian sorghum breeding program. Kalla Kéné is a dwarf and well appreciated for its stover quality. Twenty F1 selfed seeds (F2) and sixty (60) BC1F1 selfed seeds (BC1F2) were used for χ^2 test.

 Table 3: Origins, agronomic characteristics and environmental conditions of recurrent and donor parents involved in the *bmr* sorghum population development in Niger and Mali. [25]

Plant material	Agronomic characteristics of recurrent parents										
	Origin	Race	Plant type	Midrib color	Plant Height (cm)	Days Maturity (day)	Grain yield (t/ha)	Biomass yield (kg/ha)	Lodging		
Sepon82	ICRISAT	Caudatum	Tan	Green	150-170	90-105	2-2.5	Good	Resistant		
El mota	Landrace	Caudatum	Anthocyanin	White	200-250	80-90	0.8-1	Acceptable	Resistant		
Kalla kene	IER	Caudatum	Tan	White	150-190	130-140	2.8	11553	Resistant		
				D	onor Parents	ł					
Redlan bmr6	Purdue Univ.	Caudatum	Anthocyanin	Brown	130-135	95-100	1.1-1.4	Poor	Resistant		
Tx630 <i>bmr12</i>	Purdue Univ.	Caudatum	Tan	Brown	90-100	95-100	1-1.5	Poor	Resistant		
Wheatland bmr12	Purdue Univ.	Caudatum	Anthocyanin	Brown	90-100	95-100	1-1.5	Poor	Resistant		

Photo1 shows different types of midrib of RP and DP used in the bmr population development.



Photo 1: different types of sorghum leaves midrib color taken at Sotuba in 2016: A = white midrib (El mota); B = brown midrib (Wheatlandbmr12, Redlanbmr6 and Tx630bmr12) and C = dull green midrib (Sepon82)

Methodology

bmr populations development

Population development activities for the introgression of *bmr* trait into three recurrent parents took place in Mali from January 2016 until May 2017 at Sotuba Research Station. The geographic coordinates of Sotuba: 12° 39' N; 07° 56' O at 320m altitude.

January 2016-June 2016: F1 production

Crossing blocks were installed in early January 2016 off season under drip irrigation system (Photo 1). As sorghum is a short-day plant, its cultivation in January, when photoperiod is short, causes early flowering thus allowing crossing synchronization between the two parents. Nevertheless, two planting dates (27/01/2016) and 9/02/2016) for the DP parents and one date of planting for the RP (27/01/2016) were used to ensure flowering synchronization required for crossings. Furthermore, too early parents were pruned during vegetative period to allow new shoots emergence for flowering synchronization between parents. There were 10 hills planted for expected 10 plants per DP or RP parental line.

At flowering stage, RPs were hand emasculated using tweezers/forceps (Photo 2 A). The hand emasculation technique using tweezers was chosen to minimize the amount of seedlings from self-fertilization in F1 plants. Fifty to sixty flowers of each RP per cross were chosen for each crossing. Flowers from the top of each panicle were emasculated. Anthers were removed in each female and male flower. Two to three days after emasculation recurrent parents were dusted with donor parent pollen. Flowers from the bottom of the same female panicle were bagged in order to produce identical recurrent parents' seeds (Photo 2 B). Other flowers on the same female plant were completely discarded to avoid seed pollution. Likewise, each donor parent was crossed to each recurrent parent to produce F1 seed for each population. Matured crosses were harvested and kept separately. Donor parent plant seed was also selfed. RP and F1 seeds were threshed independently to avoid any seed mixture and stored at 4°C for the next F2 or BC1 population development.



Photo 2: crossing of bmr donor lines to El Mota RP (A) and to Sepon82 (B). The bottom panicle bagged (B) is used to produce recurrent parent seed and the top is to produce F1, Sotuba, 2016 offseason.

June 2016-October 2016: BC1F1 production

F1s seeds from all successful crosses and their respective parental line seeds were treated with a Caïman Rouge P (Permethrine 25 g/kg + Thirame 250 g/kg) an insecticide fungicide, pre-germinate in Petri-dishes, and then were transferred in plastic pots containing 1 kg of compost for BC1F1 seed production to secure seed. After 20 days period, F1 were transplanted in one row of 3 m. Parental seed was planted next to F1 for conformity control. Heterosis and presence of anthocyanin were used to differentiate F1 from their parental phenotypes. Hybrid vigor is easy to distinguish from parental lines. Anthocyanin (purple plant) is dominant over tan plant. If male parent is purple and the female parent tan, then the F1 deriving from these two parents must be purple. Conversely, if F1 is tan plants, this is considered a failure. These two techniques allowed the identification of few F1s plants. From F1 deriving from two purple or tan plants, segregation of *bmr* plants in F2 or BC1B2 was a sure mean of verification of true F1 cross.

Citation: Ousmane Seyni Diakité, Mamadou Aissata, Sissoko Aliou, Sanogo Sekouba, Mamoutou Kouressy, Vaksmann Michel, Daniel K. Dzidzienyo, Danquah Eric, Tongoona Pangirayi, Karim Traoré, Niaba Teme, 2018, Brown midrib 6 and 12 Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility; Journal of Basic and Applied Scientific Research, 8(6)1-10.

October 2016-June 2017: BC1F2 and F2 segregation

BC1F1 seeds obtained during 2016 cropping season crosses between F1s and recurrent parents were planted for segregation study and generation advancement to obtain BC1F2. Each BC1F1 plant seeds were germinated in Petri dish (21-31 October), transplanted in plastic pots containing 1kg of compost when primary root appeared, then transplanted in nursery field for BC1F2 plant identification. As the RP (El-mota) population heights were heterogeneous, each crossing within this population crosses was kept separate for population identity and further DNA analysis. Harvest was done in early January for the first day short cool off season period.

At harvest, each *bmr* BC1F2 panicle and F3 panicles was threshed separately. Seeds were pre-germinated in petri-dish first, then transferred in pots after the appearance of their primary root and finally transplanted in the field in late January to early February. Photoperiod sensitive sorghum cultivation in long days (starting March) delays flowering until September avoiding harvest in May or early June. To speed up panicle initiation, seedlings after 21 days of transplantation in open field, were covered (Photo 2 A) with cages every day from 5PM to 8AM, during 30 days. This artificial shortening of day length induces reproductive phase and seed for day length sensitive plants. There is a black plastic layer under each white cotton tissue for firm shade to cover each sorghum plot. All panicles were selfed during all generation advancement. BC1F2 and F3 populations were harvested for adaptation, grain yield and stover potential under rain-fed conditions in Niger in 2017 cropping season.



Photo 2: shows the cage technique (A) and breeding population selfing (B) for generation advancement





J. Basic. Appl. Sci. Res., 8(6)1-10, 2018

All BC1F1 plants were planted and non *bmr* segregating BC1F2 populations were discarded. By discarding non *bmr* population in BC1F2, we had 1/4 (3:1) *bmr* plants in a segregating population instead of 1/8 from the total number of BC1F2 population planted. It is worth notifying that segregation ratio was 1:1 in BC1F2 population for *bmr* and non populations. Identification of wild types (non *bmr* plants) could have been done on F1 or BC1F1 plants using parental polymorphic marker close to *bmr* 6 and *bmr* 12 during parental survey. Another option is to plant 10-20 seeds from BC1F1 in plastic pot filled with compost and transplant seedling to open field only genotypes showing *bmr* trait to save time, money and space.

Data analysis

Data for *bmr* segregating phenotypes were collected in the field at BC1F2 and F2 generation for Chi-square (X^2) test on every population. Chi-Square test is used in plant breeding for goodness of fit between expected and observed values. It is a statistical term which refers to how well numbers of what was expected and numbers of what is observed are the same. In this case, the number of expected *bmr* plants will be compared to observed ones as well as those expected non *bmr* to observed non *bmr* plants. This test accepts or rejects the segregation ratio based on one recessive allele (*bmr*) in our case. The following formula was used for the Chi-square test.

$$X^2 = \sum \left(\frac{a}{2}\right)$$

Where:

 X^2 = Chi-square value; Σ for sum; d = observed - expected; d represents the deviation from e or the expected value, e = expected

RESULTS

F1 production

A total of 38 seeds were obtained as F1s (Table 4) in April 2016. During the following cropping season (June to September), the F1s and their parents were grown for F2 and BC1F1 seed production and generation advancement. All the F1s exhibited white midribs confirming the dominance of white midrib over the brown midrib type. Selection based on the anthocyanin inheritance combined with heterosis was done for progenies obtained in tan x anthocyanin crosses. Any tan plant was discarded due to self-fertilization seeds. These methods allowed an easy identification of 9 true F1s among 35 crosses (Table 4). This low number of 9 F1 seeds out of 35 seeds indicates that certain selfing occurred during crossings. All progeny of possible crosses were examined:

- Sepon82 (*tan plant*) x Redlan *bmr6 (purple, anthocyanin*): among the nine (9) F1s plants, only 1 plant (F1-1-3) was anthocyanin, therefore it was considered true F1 plant. The remaining seedlings were tan plants and were discarded from the breeding populations' development.
- Sepon82 (*tan plant*) x Wheatland *bmr12 (purple, anthocyanin plant*): two (2) F1 plants were anthocyanin, thus were considered as $F_{1}s$.
- El mota (purple, anthocyanin) x Tx630 bmr12 (tan plant): twelve (12) F1 seedlings were generated and among them 3 were selected as F1s because of the heterosis observed.
- El mota (*purple anthocyanin*) x Redlan *bmr 6 (purple, anthocyanin*): both parental lines were anthocyanin. 3 F1 seedlings were produced but 2 were selected as F1s based on their visible heterosis effect.
- Kalla Kéné (tan plant) x Redlan bmr6 (purple, anthocyanin): two (2) seedlings were generated. One exhibited anthocyanin character and was selected as true F₁.
- Kalla Kéné (tan plant) x Redlan bmr12 (purple, anthocyanin): all seven (7) seedlings were tan plants and were all discarded from the breeding population development.

Table 4 indicates the number of successful crosses and Table 5 reports on the segregation ratios of *bmr* plant in F_2 population and respective Khi square value of each population.

Table 4: quantities of F1 seed produced and F1 seedling selected per cross at Sotuba April 2016.									
Crosses	'F1s' seeds count	Seedlings count	True F1s count						
on87 x Redlan <i>hmr6</i>	10	9	1						

Sepon82 x Redlan <i>bmr6</i>	10	9	1
Sepon82 x Wheatlanbmr12	2	2	2
El mota x Tx 630bmr12	14	12	3
El mota x Redlan <i>bmr6</i>	3	3	2
Kalla Kéné x Redlan <i>bmr6</i>	2	2	1
Kalla Kéné x Redlan <i>bmr12</i>	7	7	0
Total	38	35	9

Citation: Ousmane Seyni Diakité, Mamadou Aissata, Sissoko Aliou, Sanogo Sekouba, Mamoutou Kouressy, Vaksmann Michel, Daniel K. Dzidzienyo, Danquah Eric, Tongoona Pangirayi, Karim Traoré, Niaba Teme, 2018, Brown midrib 6 and 12 Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility; Journal of Basic and Applied Scientific Research, 8(6)1-10.

F2 production and segregation ratios

Table 5: segregation in the F_2 families, Sotuba December 2016.										
Population	Phenotype	Obs	Exp	df	Deviatio	d ²	d ² /e	Cal	X ² Critical	
					n (d)			X ²	value	
Sepon82//Sepon82/Redla	Dull green midrib	13	14	1	1	1	0.071	0.271	3.840	
n <i>bmr6</i>	Bmr	6	5	1	1	1	0.200			
Total		19	19	-	-	-	-	-		
Sepon82//Sepon82/Whea	Dull green midrib	14	15	1	1	1	0.066	0.266	3.840	
tlan <i>bmr12</i>	Bmr	6	5	1	1	1	0.200			
Total		20	20	-	-	-	-	-		
El mota//El mota/Tx 630 <i>bmr12</i>	White midrib	15	15	1	1	1	0.066	0.266	3.840	
	Bmr	5	5	1	1	1	0.200		3.840	
Total		20	20	-	-					
Kalla Kéné//Kalla Kéné	White midrib	15	15	1	1	1	0.066	0.266	3.840	
/Redlan <i>bmr6</i>	Bmr	5	5	1	1	1	0.200		3.840	
Total		20	20	-	-					

For a test with 1 df (degree of freedom), the "critical" value of the chi-square statistic is 3.84: when $X^2 >$ to the critical value, then the data did not fit the X^2 model or deviated from the expected value. Obs: number of *bmr* plants counted in the field out of a total of 20 plants. Exp: number of bmr plants derived from the single dominant gene segregation.

BC1F1 populations

Tables 6 gives the number of BC1F1 seeds produced per cross at Sotuba in September 2016.

Population BC1F1	Number of seeds produced
El mota//El mota/Tx630bmr12	15
Sepon82//Sepon82/wheatlandbmr12	12
Sepon82//Sepon82/Redlanbmr6	15
Kalla Kéné//Kalla Kéné/Redlanbmr6	74
Total	116

BC₁F₂ and BC₁F₃ development

Four (4) BC_1F_2 bmr populations were obtained (Table 7) and advanced to BC_1F_3 .

Table 7: Segregation ratios in the BC₁F₂ families

BC1F2 Populations	Phenotypes	Total plants	Obs	Exp	df	Deviation (d)	d ²	d²/e	X ²	X ² Critical value
Sepon82//Sepon82/Redlan	bmr	60	18	15	1	3	9	0.60	0.80	3.84
DMFO	Dull green		42	45	1	3		0.20		
Sepon82//Sepon82/Wheatlan d <i>bmr12</i>	bmr	60	13	15	1	2	4	0.26	0.35	
	Dull green		47	45	1	2		0.09		
El mota//El mota/Tx 630	bmr	60	17	15	1	2	4	0.26	0.35	
bmr12	White midrib		43	45	1	2		0.09		
Kalla Kéné// Kalla Kéné/Redlan <i>hmr6</i>	bmr	60	15	15	1	0	0	0	0	
Kene Keutan UMF0	White midrib		45	45	1	0	0	0	0	

For a test with 1 df (degree of freedom), the "critical" value of the chi-square statistic is 3.84.

DISCUSSION

After hand emasculation crosses 38 F1 seeds were obtained from almost 2000 expected seeds. This low level of success of crosses is mainly due to high temperatures occurring at this period of the year (almost 45°C) at Sotuba. In this view, [17] demonstrated that crossing sorghum at a temperature of 40°C (with low humidity) usually results in failure of seed set. Regarding the low success of crosses (only 9 true F1s over 38 seedlings), breakage of anthers and pollen pollution on tweezers tips during the emasculation process can be responsible. This hypothesis was supported by [17] who prevented about anther rupture and pollen sticking to the emasculation tool combined with heat. In addition, [16] reported that the success of hybridization varies with personal skill, the amount of injuries sustained by the floret part during the emasculation.

The midrib trait segregation in the breeding populations was verified using the chi-square test and heterosis vigor. Every breeding population was constituted of two types of phenotypes (*bmr* plants and non *bmr* plants). For a test with 1 degree of freedom, the critical value of the chi-square statistic was 3.84 (chi-square table). Consequently, a very small chi-square statistic value obtained here means that the observed data fits the expected data extremely well. In this order, our results showed no statistic deviation from the ratio of 3:1 in the segregating populations (F2s and BC1F2). Indeed, two situations were observed from our data analysis: (1) a good fit of the segregation; (2) the Chi-square values were inferior to the critical values. Our results are in harmony with those found by [3]. For the same trait, [26] also found similar result in F2 *bmr* segregating populations. Furthermore, in a cross involving a rice wild type and a mutant, [27] observed in the following F2 population a ratio of 3:1 and suggested that each mutant phenotype was caused by a recessive mutation in a single locus.

Night time of 15 hours imposed on Kalla Kéné using cage technique was critical for inducing its reproductive stage. This cage is locally manufacture and is easy manipulated.

CONCLUSION-PERSPECTIVES

Conventional hand emasculation (HE) technique used to create diversity in self pollinated crop such as sorghum is still a very practical and worth technique in the absence of molecular makers for young breeders with resources limited to use molecular techniques facility. Mali and recently Niger breeders have been using HE technique which needs skill field technicians to pursue their breeding activities while out sourcing sometime their crossings when financial opportunity is available. Opportunity to train other institution technician with limited access to molecular laboratory facility is available at Sotuba in Mali for hand emasculation training. This technique is still very useful in genes introgression for sorghum segregating populations development. However, in such circumstance, the environmental conditions such as temperature and humidity are of great importance in sorghum hybridization. This was clearly observed during the *bmr* genes transfer. The *bmr6* and *bmr12* genes were successfully introgressed in Nigerien and Malian sorghum varieties background.

HE genetic transfer of the *bmr* genes laid out the dual purpose sorghum varieties with potential high stover quality populations for the two countries. Large populations *bmr* populations are developed and are under field evaluation for grain and yield potential in Niger and Mali, two Sahelian countries facing livestock feeding issue with quality stover during dry season. Furthermore, introgression of *bmr* trait in late maturing photoperiod sensitive varieties increase both biomass productivity and quality due to their lower lignin contents.

Identification of productive and quality stover lines, experimented in pilot study with livestock holders at farmer level, will set up the opportunity for intensive milk and beef production to pave the road for stabilized cattle husbandry and to end long term free grazing conflicts.

Acknowledgements

I am grateful to SMIL/USAID for my scholarship, WACCI for PhD training. IER Mali for the facilities and implication of field technicians throughout this work.

REFERENCES

- Barriere Y., Carine, Gt, Deborah, G., Magalie, P.. 2003. Genetic variation and breeding strategies for improved cell wall digestibility in annual forage crops. A review. Animal Research, *EDP Sciences*, 52 (3), pp.193-228.
 <10.1051/animres:2003018>. <hal00889970>
- [2] Ayyangar, G. N. R. and B. W. X. Ponnaiya, 1941. The occurrence and inheritance of a bloomless sorghum. Curr. Sci. 10: 408–409.
- [3] Porter, K. S., J. D. Axtell, V. L. Lechtenberg, and V. F. Colenbrander, 1978. Phenotype, fiber composition, and in vitro dry matter disappearance of chemically induced brown midrib (bmr) mutants of sorghum. *Crop Sci.* 18: 205-208
- [4] McCollum, T., McCuistion, K., Bean, B.W., 2005. Brown Mid-rib and photoperiod-sensitive forage sorghums. Texas A&M Univ., College Station, TX.)

- Citation: Ousmane Seyni Diakité, Mamadou Aissata, Sissoko Aliou, Sanogo Sekouba, Mamoutou Kouressy, Vaksmann Michel, Daniel K. Dzidzienyo, Danquah Eric, Tongoona Pangirayi, Karim Traoré, Niaba Teme, 2018, *Brown midrib 6* and *12* Genes Introgression in Two Nigerien and One Malian Sorghum Varieties: A Practical Guide to Young Scientists with Limited Molecular Facility; Journal of Basic and Applied Scientific Research, 8(6)1-10.
- [5] Saballos A., Vermerris W., Rivera L., and Ejeta G. 2008. Allelic association, chemical characterization and saccharification properties of brown midrib mutants of sorghum (Sorghum bicolor (L.) Moench). *Bioenerg. Res.* 1:193-204
- [6] Saballos A., Sattler S., E., Sanchez E., Foster T., P., Xin Z., et al., 2012. Brown midrib2 (Bmr2) encodes the major 4-coumarate: Coenzyme A ligase involved in lignin biosynthesis in sorghum *[Sorghum bicolor* (L.) Moench]. *Plant J.* 70: 818-830.
- [7] Sattler S., E., Saballos A., Xin Z., Funnell-Harris D., L., Vermerris W. and Pedersen J., F. 2014. Characterization of Novel Sorghum brown midrib Mutants from an EMS-Mutagenized Population. *Genes/Genomes/Genetics*. Vol.4: 2115-2124.
- [8] Bout S and Vermerris W. 2003. A candidate-gene approach to clone the sorghum Brown midrib gene encoding caffeic acid O-methyltransferase. *Mol. Gen. Genomics*. 269: 205-214
- [9] Cherney, J. H., D.J.R. Cherney, D. E. Akin, and J. D. Axtell. 1991. Potential of brown-midrib low-lignin mutants for improving forage quality. *Adv. Agron.* 46:157-198.
- [10] Olivier A., L., Pedersen J., F., Grant R., J., Klopfenstein T., J. 2005. Comparative effects of the sorghum bmr-6 and bmr-12 genes: I Forage sorghum yield and quality. Crop Sci. 45:2234-2239.
- [11] Vogler R. K., Tesso T. T., Johnson K. D., Ejeta G. 2009. The effect of allelic variation on forage quality of brown midrib sorghum mutants with reduced caffeic acid O methyl transferase activity. African Journal of Biochemistry Research. Vol. 3(3), 070-076.
- [12] Rao P.S., Deshpande S., Blummel M., Reddy V.S., Hash T. 2012. Characterization of brown midrib mutants of sorghum (sorghum bicolor (L.) Moench). *The European Journal of Plant Science and Biotechnology*. 5 pages.
- [13] Jung H., G., and Fahey G., C., Jr. 1983. Nutritional implications of phenolic monomers and lignin: A review. J. Anim. Sci. 57, 206-219.
- [14] Grant R. J.;Haddad S G, Moore K J and Pedersen J F. 1995. Brown mid-rib sorghum silage for mid-lactation dairy cows. *Journal of Dairy Science* 78(9):1970-80.
- [15] Akinola A., A., Ayedun B., Abubacar M., Sheu M and Abdoulaye T. 2015. Crop residue usage and its determinants in Kano State, Nigeria. *Journal of Development and Agricultural Economics*. Vol. 7(4) 162-173
- [16] Schertz K. F., and Dalton L. G. 1980. Sorghum. In "Hybridization of Crop Plants" (W. R. Fehr and H. H. Hadley, Eds.). *American Society of Agronomy*, Madison, WI. 577-588 pp.
- [17] House L., R. 1985. A Guide to Sorghum Breeding. International Crops Research Institute for the Semi-Arid Tropics. Patancheru, India. 212p.
- [18] Rooney W.L. 2004. Sorghum Improvement-Integrating Traditional And New Technology To Produce Improved Genotypes. *Advances in Agronomy, Volume* 83. 73p.
- [19] Rooney W. L. 2001. Sorghum genetics and cytogenetics. In "Sorghum: Evolution, History, Production and Technology" (C. W. Smith and R. A. Frederiksen, Eds.). 261-307 pp.
- [20] Acquaah George. 2007. Principles of Plant Genetics and Breeding. 584p
- [21] Stephens J. C., and Holland R. F. 1954. Cytoplasmic male-sterility for hybrid sorghum seed production. *Agron.* J. 46, 20-23.
- [22] Stephens J. C., and Quinby J. R. 1934. Bulk emasculation of sorghum flowers. J. Am. Soc. Agron. 25, 233-234.
- [23] Schertz K. F., and Clark L. E. 1967. Controlling dehiscence with plastic bags for handcrosses in sorghum. Crop Sci. 7, 540-542.
- [24] Pedersen, J.F., Funnell, D.L., Toy, J.J., Oliver, A.L., Grant, R.J., 2006. Registration of Twelve Grain Sorghum Genetic Stocks Near-isogenic for the Brown Midrib Genes bmr-6 and bmr-12. *Crop Science*. 46, 491-492.
- [25] République du Niger. 2012. Catalogue National des Espèces et Variétés Végétales. 276 pages.
- [26] Nagaraja R. R., Murali Mohan S., Madhusudhana R., Umakanth AV., Satish K and Srinivas G. 2008. Inheritance of morphological characters in sorghum. *Journal of SAT Agricultural Research* 6. 3p.
- [27] Akira A., Shunichi K., Kentaro Y., Satoshi N., Hiroki T., Hiroyuki K., Hideo M., Kakoto Y., Chikako M., Muluneh T., Hideki I., Liliana C., Sophien K. and Ryohei T. 2012. Genome sequencing reveals agronomically important loci in rice using MutMap. *Nature Biotechnology*. Vol.30 (2), 174-179.

INSTRUCTION TO AUTHORS

Manuscript Submission:

Send your manuscript with attachment by mailing it to <u>info@textroad.com</u>, <u>textroadjournals@gmail.com</u> along with <u>covering letter</u>.

Manuscript Preparation:

- * Title
- * Author names and addresses
- * Abstracts (Not more than 300 words)
- * Key words
- * Introduction
- * Materials and Methods
- * Results and Discussions
- * References (Use numbering in the text instead of full references). Give full references at the end of the file
- * Photographs should be of high quality (Minimum 300-600 dpi)
- * Graphs should be in clearly visible form so that it may become easy to redraw
- * The manuscript must be submitted in MS-WORD file format.

INSTRUCTIONS TO AUTHORS

Submission

Submit manuscripts as e-mail attachment to the Editorial Office at:

textroadjournals@gmail.com or info@textroad.com along with <u>covering letter</u>. A manuscript number will be mailed to the corresponding author same day or within 48 hours. The authors may also suggest two to four reviewers for the manuscript (JBASR may designate other reviewers). There is no page limit. The submitting author takes responsibility for the paper during submission and peer review.

Terms of Submission

Papers must be submitted on the understanding that they have not been published elsewhere (except in the form of an abstract or as part of a published lecture, review, or thesis) and are not currently under consideration by another journal. The submitting author is responsible for ensuring that the article's publication has been approved by all the other coauthors. All enquiries concerning the publication of accepted papers should be addressed to <u>editor@textroad.com</u>.

Review Process

All manuscripts are reviewed by an editor and members of the Editorial Board or qualified outside reviewers. Decisions will be made as rapidly as possible, and the journal strives to return reviewers' comments to authors within one or two weeks. The editorial board will re-review manuscripts that are accepted pending revision. It is the goal of the JBASR to publish manuscripts within 4 weeks after submission.

Style of Manuscripts

Manuscripts should be written in clear, concise and grammatically correct English (with 10 font size and Times New Roman font style) so that they are intelligible to the professional reader who is not a specialist in any particular field. Manuscripts that do not conform to these requirements and the following manuscript format may be returned to the author prior to review for correction. The entire manuscript, including references, should be typed single spaced on one side of the paper. All pages should be numbered consecutively in the bottom centre starting from the title page. The manuscript should be presented in the following order.

Title and Authorship Information

The title should be a brief phrase (capitalize first letter of each word in the title) 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.

Abstract

All manuscripts should not exceed 250-300 words and should describe the scope, hypothesis or rationale for the work and the main findings. Complete sentences, active verbs, 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.

Keywords

Key words (5-7 words) should be provided below the Abstract to assist with indexing of the article. These should not duplicate key words from the title.

Introduction

This section should include sufficient background information, provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. The aims of the manuscript should be clearly stated. The introduction should not contain either findings or conclusions. It should be understandable to colleagues from a broad range of scientific disciplines.

Materials and Methods

This should be complete enough to provide sufficient detail to allow the work to be repeated by others. 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

Results should be presented in a logical sequence in the text, tables and figures; repetitive presentation of the same data in different forms should be avoided. The results should not contain material appropriate to the Discussion. It should be written in the past tense when describing findings in the authors' experiments. Results should be explained, but largely without referring to the literature.

Discussion

The discussion should consider the results in relation to any hypotheses advanced in the Introduction and place the study in the context of other work. Results and Discussion sections can be combined.

Conclusions

If an optional conclusion section is used, its content should not substantially duplicate the abstract.

Acknowledgment

The acknowledgments of people, grants, funds, etc should be brief.

References

Bibliographic references in the text appear like [1, 2, 5, 6], using square brace in superscript. References should be numbered consecutively, with style:

Journal paper:

1. Hadjibabaie, M., N. Rastkari, A.Rezaie and M. Abdollahi, 2005. The Adverse Drug Reaction in the Gastrointestinal Tract: An Overview. Intl. J. Pharmacol., 1 (1): 1-8.

Books:

1. Daniel A. Potter, 2002. Destructive turfgrass insects: Biology, diagnosis and control. Wiley Canada Publishers, pp: 24-67.

Chapters in Book:

1. Bray R.A., 1994. The leucaena psyllid. In: Forage Tree Legumes in Tropical Agriculture (eds R.C. Gutteridge and H.M. Shelton) pp. 283–291. CAB International, Oxford.

Titles of journals should be given in full. 'In press' can only be used to cite manuscripts actually accepted for publication in a journal. Citations such as 'manuscript in preparation' or 'manuscript submitted' are not permitted. Data from such manuscripts can only be mentioned in the text as 'unpublished data'.

A Report:

1. Makarewicz, J.C., T. Lewis and P. Bertram, 1995. Epilimnetic phytoplankton and zooplankton biomass and species composition in Lake Michigan, 1983-1992. U.S. EPA Great Lakes National Program, Chicago, IL. EPA 905-R-95-009.

Conference Proceedings:

1. Stock, A., 2004. Signal Transduction in Bacteria. In the Proceedings of the 2004 Markey Scholars Conference, pp: 80-89.

A Thesis:

1. Strunk, J.L., 1991. The extraction of mercury from sediment and the geochemical partitioning of mercury in sediments from Lake Superior, M. S. thesis, Michigan State Univ., East Lansing, MI.

Tables and Equations

Tables and equations should not be submitted in a format exceeding the A4 page size (in portrait form). **All tables should be embedded within the manuscript, and must be captioned and numbered sequentially.** 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.

Figures / Illustrations / Photographs

Graphics should be supplied as high resolution (at least 300-600 dp.i.) electronic files. Digital images supplied only as low-resolution print-outs cannot be used. Graphs, diagrams, chromatograms, photos, etc. should be prepared as clear, original positives, suitable for reproduction. All figures should be embedded within the manuscript, and must be captioned and numbered sequentially.

Proofs

Proofs will be sent via e-mail as an Acrobat PDF file (e-mail attachment) and should be returned within 3 days of receipt. 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.

Check List

We recommend that you ask a colleague to read over your paper prior to submission to ensure it is of a high standard and conforms to a high level of scientific writing.

Before submission of your manuscript, please check that:

- All references cited in the text are included in the reference section.
- All figures and tables are cited in the text.
- Figures are at least 300 d.p.i.
- The pages are numbered.

Copyright © 2018, TEXTROAD Publishing Corporation







pyright © 2018, TEXTROAD. All Rights Reserv TEXTROAD Publishing Corporation