Online ISSN : 2249-4626
Print ISSN : 0975-5896
DOI : 10.17406/GJSFR

Global Journal

of Science Frontier Research: D

Agriculture & Veterinary

Yield of Maize Zea Mays

Diagnosis of Phenological Damage

Highlights

Satellite Remote Sensing Data

Improved Forage Technologies

Discovering Thoughts, Inventing Future

VOLUME 18 ISSUE 2 VERSION 1.0

© 2001-2018 by Global Journal of Science Frontier Research, USA

Global Journal of Science Frontier Research: D
Agriculture & Veterinary

Global Journal of Science Frontier Research: D
Agriculture & Veterinary

Volume 18 Issue 2 (Ver. 1.0)

Open Association of Research Society

© Global Journal of Science Frontier Research. 2018.

All rights reserved.

This is a special issue published in version 1.0 of "Global Journal of Science Frontier Research." By Global Journals Inc.

All articles are open access articles distributed under "Global Journal of Science Frontier Research"

Reading License, which permits restricted use. Entire contents are copyright by of "Global Journal of Science Frontier Research" unless otherwise noted on specific articles.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without written permission.

The opinions and statements made in this book are those of the authors concerned. Ultraculture has not verified and neither confirms nor denies any of the foregoing and no warranty or fitness is implied.

Engage with the contents herein at your own risk.

The use of this journal, and the terms and conditions for our providing information, is governed by our Disclaimer, Terms and Conditions and Privacy Policy given on our website http://globaljournals.us/terms-and-condition/menu-id-1463/

By referring / using / reading / any type of association / referencing this journal, this signifies and you acknowledge that you have read them and that you accept and will be bound by the terms thereof.

All information, journals, this journal, activities undertaken, materials, services and our website, terms and conditions, privacy policy, and this journal is subject to change anytime without any prior notice.

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN):
USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*
Sponsors: Open Association of Research Society
Open Scientific Standards

Publisher's Headquarters office

Global Journals® Headquarters
945th Concord Streets,
Framingham Massachusetts Pin: 01701,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals Pvt Ltd
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investors@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Excluding Air Parcel Charges):

Yearly Subscription (Personal & Institutional)
250 USD (B/W) & 350 USD (Color)

Editorial Board

Global Journal of Science Frontier Research

Dr. John Korstad

Ph.D., M.S. at California State University
Professor of Biology
Department of Biology Oral Roberts University

Dr. Rafael Gutiérrez Aguilar

Ph.D., M.Sc., B.Sc., Psychology (Physiological). National Autonomous University of Mexico.

Andreas Maletzky

Zoologist, University of Salzburg, Department of Ecology and Evolution Hellbrunnerstraße, Salzburg Austria, Universitat Salzburg, Austria

Tuncel M. Yegulalp

Professor of Mining, Emeritus
Earth & Environmental Engineering
Henry Krumb School of Mines, Columbia University
Director, New York Mining and Mineral
Resources Research Institute, USA

Nora Fung-yee TAM

DPhil
University of York, UK
Department of Biology and Chemistry
MPhil (Chinese University of Hong Kong)

Prof. Philippe Dubois

Ph.D. in Sciences
Scientific director of NCC-L, Luxembourg
Full professor,
University of Mons UMONS, Belgium

Dr. Mazeyar Parvinzadeh Gashti

Ph.D, M.Sc., B.Sc. Science and Research Branch of Islamic Azad University, Tehran, Iran
Department of Chemistry & Biochemistry
University of Bern, Bern, Switzerland

Dr. Eugene A. Permyakov

Institute for Biological Instrumentation
Russian Academy of Sciences, Director, Pushchino State Institute of Natural Science, Department of Biomedical Engineering, Ph.D., in Biophysics
Moscow Institute of Physics and Technology, Russia

Prof. Dr. Zhang Lifei

Dean, School of Earth and Space Sciences
Ph.D., Peking University
Beijing, China

Prof. Jordi Sort

ICREA Researcher Professor
Faculty, School or Institute of Sciences
Ph.D., in Materials Science, Autonomous University of Barcelona, Spain

Dr. Matheos Santamouris

Prof. Department of Physics
Ph.D., on Energy Physics
Physics Department
University of Patras, Greece

Dr. Bingsuo Zou

Ph.D. in Photochemistry and Photophysics of Condensed Matter
Department of Chemistry, Jilin University,
Director of Micro- and Nano- technology Center

Dr. Gayle Calverley

Ph.D. in Applied Physics University of Loughborough, UK

Dr. Linda Gao

Ph.D. in Analytical Chemistry,
Texas Tech University, Lubbock,
Associate Professor of Chemistry,
University of Mary Hardin-Baylor

Dr. Richard B Coffin

Ph.D., in Chemical Oceanography
Department of Physical and Environmental
Texas A&M University, USA

Dr. Indranil Sen Gupta

Ph.D., Mathematics, Texas A & M University
Department of Mathematics, North Dakota State University, North Dakota, USA

Prof. Ulrich A. Glasmacher

Institute of Earth Sciences, University Heidelberg, Germany, Director of the Steinbeis Transfer Center, TERRA-Explore

Dr. Alicia Esther Ares

Ph.D. in Science and Technology,
University of General San Martin, Argentina
State University of Misiones, US

Dr. Fabiana Barbi

B.Sc., M.Sc., Ph.D., Environment, and Society,
State University of Campinas, Brazil
Center for Environmental Studies and Research
State University of Campinas, Brazil

Dr. Lev V. Eppelbaum

Ph.D. Institute of Geophysics,
Georgian Academy of Sciences, Tbilisi
Assistant Professor Dept Geophys & Planetary Science,
Tel Aviv University Israel

Dr. Yiping Li

Ph.D. in Molecular Genetics,
Shanghai Institute of Biochemistry,
The Academy of Sciences of China, Senior Vice Director,
UAB Center for Metabolic Bone Disease

Dr. A. Heidari

Ph.D., D.Sc
Faculty of Chemistry
California South University (CSU), United States

Dr. Maria Gullo

Ph.D., Food Science, and Technology
University of Catania
Department of Agricultural and Food Sciences
University of Modena and Reggio Emilia, Italy

Dr. Qiang Wu

Ph.D. University of Technology, Sydney
Department of Machematics, Physics and Electrical Engineering
Northumbria University

Dr. Bingyun Li

Ph.D. Fellow, IAES
Guest Researcher, NIOSH, CDC, Morgantown, WV
Institute of Nano and Biotechnologies
West Virginia University, US

Dr. Giuseppe A Provenzano

Irrigation and Water Management, Soil Science, Water Science Hydraulic Engineering
Dept. of Agricultural and Forest Sciences
Universita di Palermo, Italy

Dr. Sahraoui Chaieb

Ph.D. Physics and Chemical Physics
M.S. Theoretical Physics
B.S. Physics, École Normale Supérieure, Paris
Associate Professor, Bioscience
King Abdullah University of Science and Technology

Dr. Arshak Poghossian

Ph.D. Solid-State Physics
Leningrad Electrotechnical Institute, Russia
Institute of Nano and Biotechnologies
Aachen University of Applied Sciences, Germany

Dr. Lucian Baia

Ph.D. Julius-Maximilians University Würzburg, Germany
Associate professor
Department of Condensed Matter Physics and Advanced Technologies Babes-Bolyai University, Romania

Dr. T. David A. Forbes

Associate Professor and Range Nutritionist
Ph.D. Edinburgh University - Animal Nutrition
M.S. Aberdeen University - Animal Nutrition
B.A. University of Dublin- Zoology.

Dr. Mauro Lenzi

Ph.D.
Biological Science,
Pisa University, Italy
Lagoon Ecology and Aquaculture Laboratory
Orbetello Pesca Lagunare Company

Dr. Fotini Labropulu

Mathematics - Luther College
University of Regina, Ph.D., M.Sc. in Mathematics
B.A. (Honours) in Mathematics
University of Windsor
Web: luthercollege.edu/Default.aspx

Dr. Mihaly Mezei

Associate Professor
Department of Structural and Chemical Biology
Mount Sinai School of Medical Center
Ph.D., Etvs Lornd University, New York University, United State

Dr. Miguel Angel Ariño

Professor of Decision Sciences
IESE Business School
Barcelona, Spain (Universidad de Navarra)
Ph.D. in Mathematics, University of Barcelona, Spain

Dr. Wen-Yih Sun

Professor of Earth and Atmospheric Sciences
Purdue University, Director, National Center for Typhoon and Flooding, United State

Dr. Della Ata

BS in Biological Sciences
MA in Regional Economics, Hospital Pharmacy
Pharmacy Technician Educator

Dr. Shengbing Deng

Departamento de Ingeniería Matemática,
Universidad de Chile.
Facultad de Ciencias Físicas y Matemáticas.
Blanco Encalada 2120, piso 4.
Casilla 170-3. Correo 3. - Santiago, Chile

Dr. Claudio Cuevas

Department of Mathematics
Universidade Federal de Pernambuco
Recife PE
Brazil

Dr. Yap Yee Jiun

B.Sc.(Manchester), Ph.D.(Brunel), M.Inst.P.(UK)
Institute of Mathematical Sciences,
University of Malaya,
Kuala Lumpur, Malaysia

Dr. Eman M. Gouda

Biochemistry Department,
Faculty of Veterinary Medicine,
Cairo University,
Giza, Egypt

Dr. Latifa Oubedda

National School of Applied Sciences,
University Ibn Zohr, Agadir, Morocco
Lotissement Elkhier N°66, Bettana Salé Maroc

Dr. Bing-Fang Hwang

Ph.D., in Environmental and Occupational Epidemiology,
Professor, Department of Occupational Safety
and Health, China Medical University, Taiwan

Dr. Hai-Linh Tran

Ph.D. in Biological Engineering
Department of Biological Engineering
College of Engineering, Inha University, Incheon, Korea

Dr. Baziotis Ioannis

Ph.D. in Petrology-Geochemistry-Mineralogy
Lipson, Athens, Greece

Angelo Basile

Professor
Institute of Membrane Technology (ITM)
Italian National, Research Council (CNR), Italy

Dr. Vishnu Narayan Mishra

B.Sc.(Gold Medalist), M.Sc. (Double Gold Medalist), Ph.D.
(I.I.T. Roorkee)

Dr. Yaping Ren

School of Statistics and Mathematics
Yunnan University of Finance and Economics
Kunming 650221, China

Dr. Xianghong Qi

University of Tennessee
Oak Ridge National Laboratory
Center for Molecular Biophysics
Oak Ridge National Laboratory
Knoxville, TN 37922, United States

Dr. Gerard G. Dumancas

Postdoctoral Research Fellow,
Arthritis and Clinical Immunology Research Program,
Oklahoma Medical Research Foundation
Oklahoma City, OK, United States

Dr. Vladimir Burtman

Research Scientist
The University of Utah, Geophysics, Frederick Albert
Sutton Building, 115 S 1460 E Room 383
Salt Lake City, UT 84112, US

Dr. Bondage Devanand Dhondiram

Ph.D.
No. 8, Alley 2, Lane 9, Hongdao station,
Xizhi district, New Taipei city 221, Taiwan (ROC)

Dr. Yaping Ren

School of Statistics and Mathematics
Yunnan University of Finance and Economics
Kunming 650221, China

Contents of the Issue

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Wheat Yield Prediction in Bangladesh using Artificial Neural Network and Satellite Remote Sensing Data

By Kawsar Akhand, Mohammad Nizamuddin & Leonid Roytman
The City College of New York, United States

Abstract- The main goal of the agricultural sector in Bangladesh is to maintain food security for a population of 160 million. Due to the increase in population and the decrease of agricultural land, this sector is under pressure to ensure food for its vast population. Bangladesh is predominantly an agricultural based country, and agriculture contributes remarkably to the national economy, employment rates, and consumption. Reliable and up-to-date information on crop yield predictions before the harvest is vital for the Government and its stakeholders to maintain food security, reservation, and trade. The goal of this paper is to investigate the strength of satellite data products as predictors for wheat yield prediction and to develop a prediction model using an Artificial Neural Network (ANN) simulation tool. Vegetation health indices Vegetation Condition Index (VCI), and Temperature Condition Index (TCI) developed by National Oceanic and Atmospheric Administration (NOAA) computed from Advanced Very High-Resolution Radiometer (AVHRR) sensor are tested for wheat yield prediction. Wheat is the second most vital food grain after rice in Bangladesh and plays a significant role in meeting the country's food requirements. The predicted values from this model are compared with the actual yield. The result obtained from this model shows higher prediction accuracies.

Keywords: *remote sensing, artificial neural network, prediction, agriculture, wheat yield.*

GJSFR-D Classification: *FOR Code: 820507*

Strictly as per the compliance and regulations of:

© 2018. Kawsar Akhand, Mohammad Nizamuddin & Leonid Roytman. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Wheat Yield Prediction in Bangladesh using Artificial Neural Network and Satellite Remote Sensing Data

Kawsar Akhand [α], Mohammad Nizamuddin [σ] & Leonid Roytman [ρ]

Abstract- The main goal of the agricultural sector in Bangladesh is to maintain food security for a population of 160 million. Due to the increase in population and the decrease of agricultural land, this sector is under pressure to ensure food for its vast population. Bangladesh is predominantly an agricultural based country, and agriculture contributes remarkably to the national economy, employment rates, and consumption. Reliable and up-to-date information on crop yield predictions before the harvest is vital for the Government and its stakeholders to maintain food security, reservation, and trade. The goal of this paper is to investigate the strength of satellite data products as predictors for wheat yield prediction and to develop a prediction model using an Artificial Neural Network (ANN) simulation tool. Vegetation health indices Vegetation Condition Index (VCI), and Temperature Condition Index (TCI) developed by National Oceanic and Atmospheric Administration (NOAA) computed from Advanced Very High-Resolution Radiometer (AVHRR) sensor are tested for wheat yield prediction. Wheat is the second most vital food grain after rice in Bangladesh and plays a significant role in meeting the country's food requirements. The predicted values from this model are compared with the actual yield. The result obtained from this model shows higher prediction accuracies.

Keywords: remote sensing, artificial neural network, prediction, agriculture, wheat yield.

I. Introduction

Agriculture is the most influential strategic sector all over the world; this sector provides food and the prime means of livelihood 7.6 billion people. Wheat is one of the most important staple foods; it is ranked second as cereal grain after rice and consumes throughout the world. It is not only a staple food, but it is also an excellent cash crop because of its dominance in world trade and commerce. Besides this, the cultivation of wheat is comparatively easier than the other grain crops, has a relatively short duration of growing period and has very fair yield rate. It is currently the most widely cultivated crop, and it covers more area than any other food crop in the world. It is an abundant source of carbohydrates and protein. It provides 20% of the daily food calories and protein for 4.5 billion people all around the world [1].

Authors α σ ρ: The City College of New York, Department of Electrical Engineering, 160 Convent Avenue, NY-10031, USA.
e-mails: kawsar0109@gmail.com, nizam89@gmail.com, roytman@ccny.cuny.edu

According to the Food and Agriculture Organization (FAO) of United Nations, rice and wheat are the world's two most important food grains; their respective scenarios in production are 493.7 & 732.4 million tons, in cultivated area are 163.19 & 220.41 million hectare and in trade are 45 & 156 million tons in the year 2014/15 which clearly indicates the dominance of wheat in global food security.

Bangladesh is known to be a densely populated country in the world; about 160 million people live on a small land 147,570 km^2, where the agricultural sector is under immense pressure to meet the increasing demand of food for its big amount, and ever-increasing population. Fundamentally, Bangladesh has an agro-based economy and agriculture plays a vital role in its economy, food security, employment and poverty reduction. As the single largest contributor to the national economy and employment generation, agriculture contributes about 17% to Gross Domestic Product (GDP), and around 45% of the total labor force is employed in this sector [2]. Wheat is the second most important cereal crop in Bangladesh next to rice. It is known to be the food supplement to rice as dietary preferences of Bangladeshi people and in economic and consumption importance.

An accurate, authentic and timely prediction of crop yield is of fundamental importance to the government, growers, stakeholders, and policymakers for monitoring food security and planning about crop markets. The statistical yield data is a manual collection of field data done via an annual/seasonal sample survey which is labor and time intensive and requires several months after harvest to release officially. On the other hand, crop yield can be effectively forecast before harvest using remote sensing technology. Yield forecast provides valuable information that can be used to maintain adequate food stocks, make appropriate food policies, improve market transactions, set national prices, optimize the utilization of storage, transaction and processing facilities, and make effective decisions regarding the export or import trade [3]. At present, different methodologies and models are used by researchers to predict agriculture production. These include multiple regression, exponential smoothing, adaptive, stochastic time series, iterative, least-squares, fuzzy logic, expert system and artificial neural network

© 2018 Global Journals

[4]. ANN uses widely as a crop yield forecasting application because of its ability to learn complicate and nonlinear relationships between the different parameters of crop growth and yield such as temperature, plant biomass, leaf area index, moisture, solar radiation, and photosynthesis. These parameters also use as variables for crop simulation model [5].

Agricultural production is intensely influenced by weather components like the temperature, solar energy, humidity, precipitation, atmospheric gases, etc., of an area and wheat yields are controlled by them [6]. The weather network in Bangladesh is not sufficient for the timely and efficient collection of weather information regarding crop development. On the other hand, satellite remote sensing technologies are capable, available and cost-effective for monitoring and identifying crop growth stages, phenology, yield and classes in a timely fashion [7]. Besides this, NOAA developed vegetation health indices VCI and TCI estimating cumulative moisture and temperature respectively of an area which are very useful for remote sensing researchers in the agriculture field. Normalized Difference Vegetation Index (NDVI) and Brightness Temperature (BT) characterize healthy and unhealthy vegetation of the area and VCI and TCI are derived from them. VCI and TCI values have a strong correlation with these indices and agricultural crop production during the critical period of crop development [8]. In this study, we developed a methodology for predicting wheat yield in Bangladesh using remote sensing technology and ANN simulation tool, and we also examined the usability of AVHRR-based vegetation health products VCI and TCI indices as predictors for early estimation of wheat yield in Bangladesh at approximately six to eight weeks before harvest. The efficiency of this model was evaluated for different hidden neurons to determine the optimum performance.

II. Study Area

The study area is Bangladesh, located in South Asia between 20°34′ to 26°38′ North latitudes and 88°01′ to 92°42′ East longitudes. Bangladesh has a total area of 147,570 km^2 and is bordered by India in the West, North, and East by a 4,095 km land frontier and by Myanmar in the Southeast by 193 km land and water frontier. The climate of Bangladesh is tropical monsoon, with three main seasons: a hot and humid summer season (March-May), a warm and humid monsoon season (June-October) and a cold and dry winter season (November-February). The Country's temperature falls between 12-35°C, humidity range is 65-90%, and the annual average rainfall varies from 1500 mm to 5000mm [9]. There is a perfect relationship between optimum wheat cultivation weather and the weather of Bangladesh. Notably, Bangladeshi weather is favorable for wheat cultivation. Wheat is grown well in the temperate and sub-temperate zones of the world. It is a cold-loving crop, and a high level of moisture requires in the early period of the plantation. Every crop has an optimum temperature range for its maximum production. The optimum temperature for wheat growing is 25°C with minimum and maximum growing temperature is 3-4°C and 32°C respectively [10]. Wheat is one of the principal winter crops in Bangladesh and is planted in November/December and harvested in March/April. The lifetime of the wheat crop is approximately 90-120 days depending on the wheat variety and local weather conditions. During the cultivation season, November to February is the cooler and drier winter, and March-April is the hot and humid summer season. Temperature has a significant impact on wheat cultivation such as high-temperature stresses during reproduction and grain filling stages are some of the key concerns of yield loss. On the other hand, the higher temperature boosts plant growth, flowering, and maturation. Optimum yield also requires an adequate source of moisture availability during the growing season. Therefore, seeding time is very crucial for optimum yield and the optimum seeding time is between 15th-30th November [11]. Wheat plants are affected by cold or frost injury at any stage of growth and grow slowly during winter. Maximum production depends on tillers/plant, optimum plant population, grains/spike and healthy vegetation which are related to temperature and moisture conditions of the cultivated area. A maximum of 5-7 tillers/plant form throughout the life of wheat plants. The maximum number of tillers mature, and optimum plant populations occur within 50 days of sowing which is until January [12]. For this study, we used VCI and TCI data for weeks 1-4 which are the month of January because this month is most sensitive for crop condition such as the development of healthy vegetation and better production of wheat yield.

III. Remote Sensing and Agriculture

Remote Sensing (RS) is the science of obtaining information about an area, object or phenomenon from a distant location without having physical contact or interfering with that area, object or phenomenon similar to the human acquisition of information through the sense of sight. RS is a technique that makes it possible to monitor the earth's resources and to gather real-time data from unreachable and dangerous areas. The dominant principle of RS is the spectral signature of the object because every object responds differently based on the different regions of the electromagnetic spectrum. By spectral signature characteristic RS responses are used to distinguish different materials and their properties such as vegetation, bare soil, cloud, and water. In remote sensing methods, data acquire as an image which represents the area being observed using special

© 2018 Global Journals

types of sensors such as aerial cameras, scanners, and radar mounted on a satellite, aircraft or other spacecraft. To extract the required information from the image which will reflect the properties of the observed area, image analysis and interpretation requires. Therefore, RS is also known as a multi-disciplinary science which is a combination of optics, electronics, spectroscopy, photography, computer, satellite, and telecommunication, etc. [13]. RS applications are successfully devoted to agricultural sector which includes: (a) estimation of crop yield, biomass and crop acreage (b) monitoring vegetation vigor and thermal stress (c) assessment of crop phonological development and (d) mapping cropland and land use/land cover changes [14].

IV. Data Acquisition

Wheat yield statistical data and AVHRR sensor based remote sensing satellite data for 24 years (1988-2011) are used in this research.

a) Wheat Yield Official Statistical Data

Wheat yield data are collected from 'The Yearbook of Agricultural Statistics of Bangladesh' which contains exclusively agriculture-related data and is regularly published by the Bangladesh Bureau of Statistics (BBS). BBS conducts the core agricultural statistics and generates data on the types of crop, production, yield, cultivation area, etc., and is responsible for accumulation, compilation, and dissemination of statistical data for the entire national system. It is a governmental authority and provides reliable, accurate and timely statistics of agricultural production. It conducts two types of agricultural statistics (a) structural and (b) annual. Structural statistics performs according to Food and Agriculture Organization (FAO) guidelines by collecting data through full count/sample census, normally at an interval of 10-year. The annual statistics performs by collecting data through annual/seasonal sample surveys. In this paper, we used annual statistical yield data. Yield (ton/hectare) was calculated by dividing total wheat production (tons) by the total sown area (hectare) [2].

b) Satellite-Based Remote Sensing Data

In this study, AVHRR sensor based vegetation health product (VHP) developed by NOAA was used to develop a model for predicting wheat yield in Bangladesh. The AVHRR flown on NOAA polar-orbiting satellites is a scanning radiometer (sensor) which has six channels three solar (visible-near infrared) and three thermal infrared to measure solar energy reflected/emitted from the earth surface. VHP derived products vegetation condition index (VCI) characterizing moisture condition and temperature condition index (TCI) characterizing thermal condition derived from NDVI and BT values acquired from the AVHRR onboard NOAA polar-orbiting satellites. The detailed methods and algorithms for calculating weekly VCI and TCI values are presented in Kogan [15, 16, 17, 18]. This paper briefly mentions some steps which are: (a) the VHP data were developed from Global Area Coverage (GAC) data, which was generated by sampling and mapping the AVHRR 1 km daily reflectance in visible (ch1, 0.58–0.68μm), near infrared (ch2, 0.72–1.00μm), and two infrared bands (ch4, 10.3–11.3μm and Ch5, 11.5–12.5μm) to a 4 km map; (b) NDVI was calculated from pre and post launch calibrated visible and near infrared reflectance using the formula:

$$NDVI = (NIR - VIS) / (NIR + VIS) \quad (1)$$

(c) The ch4 IR values were converted into BT, which were corrected for sensor's non-linear behavior; (d) the weekly composite value of NDVI was generated by selecting the largest NDVI for each pixel. NDVI was adjusted using statistical techniques; (e) a digital smoothing filter was used to eliminate the high-frequency noise (clouds, Sun, and sensor angular effects, etc.) from NDVI and BT weekly time series; (f) NDVI and BT climatology were calculated from multi-year smoothed NDVI and BT. Climatology variables the maximum and minimum values of NDVI and BT during 1988-2011 were calculated for each of 52 weeks on a pixel by pixel basis.

Vegetation health products (VHP) VCI and TCI characterize moisture, and thermal conditions respectively were calculated as:

$$VCI = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \times 100 \quad (2)$$

$$TCI = \frac{BT_{max} - BT}{BT_{max} - BT_{min}} \times 100 \quad (3)$$

Where, NDVI, NDVImin, and NDVImax (BT, BTmin, and BTmax) represent the smoothed weekly NDVI (BT), their multi-year absolute minimum and maximum respectively. VCI and TCI indices are numeric values on a scale of 0 to 100. VCI changes from 0 to 100, reflecting moisture condition changes from extreme stress to favorable and TCI changes from 0 to 100 reflecting thermal condition changes from dryness (extreme stress) to healthy (favorable). The value 50 for both VCI and TCI corresponds to an average condition [15].

V. Materials and Methods

a) ANN for Predicting Wheat Yield

ANN is a mathematical model motivated from the human central nervous system in the same manner as the brain process information, and it consists of an interconnecting group of simple elements known as 'nodes', 'neurons', and 'processing elements'. It is an intelligent system that can manipulate complex data and to learn input-output correlation by adjusting the weight and bias values to produce targeted output. As a

© 2018 Global Journals

processing unit of NN, each neuron consists of input, a summer, a bias, a transfer function and an output to process and compute values provide from connected inputs. A particular targets lead to desire outputs by adjusting or training the network [19]. The network adjustment process accomplishes based on a comparison between the targets and predicted values as demonstrated in Fig. 1.

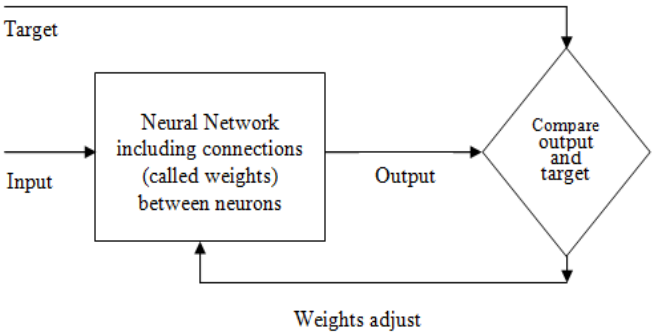


Fig. 1: Artificial neural network generic structure

A nonlinear autoregressive with external (exogenous) input or NARX neural network time series tool was used to develop a wheat yield prediction model for this study. It can be written as the Equation 4 below:

$$y(t)=f(y(t-1),y(t-2),\ldots,y(t-d),x(t-1),x(t-2),\ldots x(t-d)) \quad (4)$$

Here x(t) is the input time series, and y(t) is the target time series. The model predicts the time series value of y(t) from 'd' past values of y(t) and the same period of past values of another time series x(t). For our study, x(t) is the vegetation health indices weekly VCI and TCI, and y(t) is the wheat yield statistical data. The simulated view of the NN model is shown in Fig. 2.

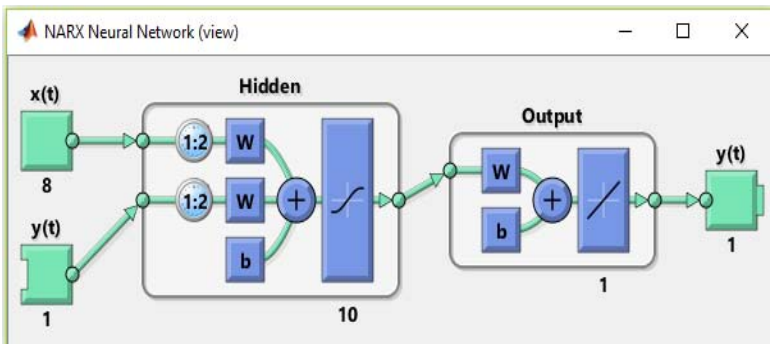


Fig. 2: Simulated diagram of wheat yield prediction model

b) Input Parameters

In this study, we used an AVHRR sensor based satellite data products weekly VCI and TCI data for weeks 1-4 as inputs and statistical wheat yield data as the target for the same period of 24 years from 1988-2011. Here a week is defined is based on the year such as week 0ne covers days of the year 1 to 7 (1st week of January). The input is a 1×24 cell array of 8×1 matrices, representing dynamic data 24-time steps of 8 elements (VCI1-VCI4 and TCI1-TCI4) and the target (wheat yield) is a 1×24 cell array of 1×1 matrices, representing dynamic data 24-time steps of 1 element. For training, validation and testing of the network the input and target data were randomly divided into 70% for training, 15% for validating and 15% for testing.

c) Weight and Bias

Weight and bias are two significant parameters, and they are known to be the adjustable variables for NN training process. They are changed according to the error (reduce error) between the target and predicted values to generate the optimum output [20]. Each element of the input vector connects with every neuron in the hidden layer through input weight matrix **IW**, and hidden layer output connects to output neuron through a layer weight matrix **LW**. Every neuron has its own bias. Fig. 3 shows the connection between weight and bias values. There are total 201 weight and bias values that come up from the proposed model network simulation. As each neuron has its own bias out of 201, there are 11 bias values (10 hidden and 1 output neurons), and remaining 190 are weight values. Weight and bias matrices generated by a Matlab simulation illustrate below where **b**, **IW**, and **LW** represent the bias, input weight and layer weight respectively.

© 2018 Global Journals

b = 2×1 cell array: {10×1 double}
{[-1.0073]}
IW = 2×2 cell array: {10×16 double} {10×2 double}
{0×0 double} {0×0 double}
LW = 2×2 cell array: {0×0 double} {0×0 double}
{1×10 double} {0×0 double}

d) ANN Model Architecture

The proposed model is a two-layer (hidden layer and output layer) feed-forward Artificial Neural Network with a back-propagation learning algorithm as illustrated in Fig. 3. The connections of weights between inputs and hidden nodes, hidden nodes to the output node and biases with nodes are shown in Fig. 3.

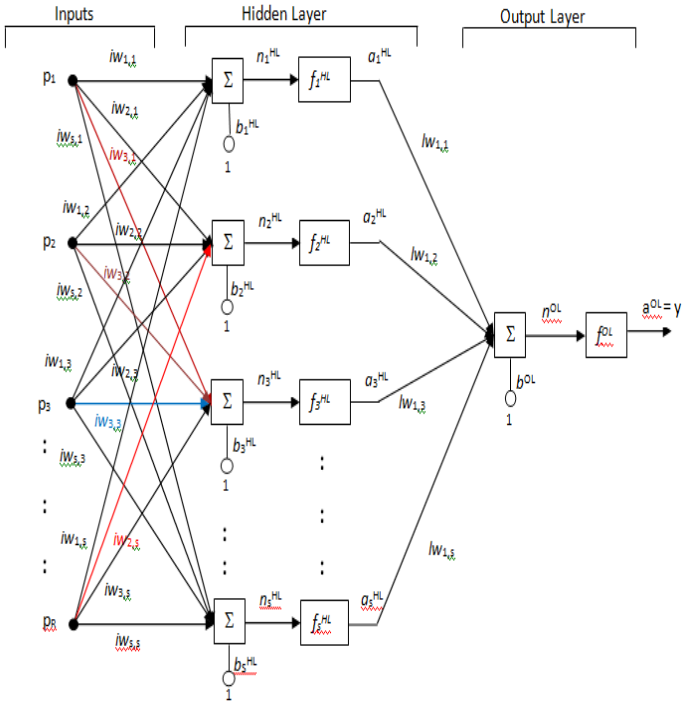


Fig. 3: Schematic diagram of feed-forward back propagation ANN with layers and connections

The output of this model is also known as the network simulation output and is produced according to the following equation:

$$y = \mathbf{f}^{OL}(\mathbf{LW}^{OL}\ \mathbf{f}^{HL}(\mathbf{IW}^{HL}\ \mathbf{p} + \mathbf{b}^{HL}) + \mathbf{b}^{OL}) \quad (5)$$

Here,
HL- Hidden layer
OL- Output layer
y = Model output (simulated output)
$\mathbf{f}^{OL}$ = Linear transfer function for output layer neuron
$\mathbf{f}^{HL}$ = Log-sigmoid transfer function for hidden layer's neuron
$\mathbf{LW}^{OL}$ = Layer weight matrix for the hidden layer to the output layer
$\mathbf{IW}^{HL}$ = Input weight matrix for hidden layer (from input variables to hidden layer's neurons)
p = Input vector (R × Q matrix, R is the number of input variables, and Q is the number of elements each variable has)
$\mathbf{b}^{HL}$ = Bias vector for hidden layer neurons
$\mathbf{b}^{OL}$ = Bias vector for the output layer

The key issues around to designing a neural network-based prediction model are to select the appropriate number of neurons for hidden layer and activation function for both hidden and output layer because the optimum performance of the model depends on them. For our model, we chose the trial and error method to select the optimum number of neurons for hidden layer. We tested 4,6, 8, 10, 12, 15, 20 and 25 neurons for hidden layer and selected 10(ten) neurons for our proposed model as it provides less mean squared error compared to others as well as less error of prediction. We used 1 (one) neuron for the output layer because it was selected based on the number of element category in the target. Since transfer function, also known as activation function, has a dominant impact on the neuron's output we used sigmoid transfer function for the hidden layer and linear transfer function for output layer neuron. A characteristic of the sigmoid transfer function is that it takes input values between plus and minus infinity and compresses the output into a range between 0 & 1 and the linear transfer function which produce its input as the output.

e) Training The Network

Training is a paramount attribute of the neural network simulation software. Therefore, selection of

© 2018 Global Journals

appropriate training functions is a vital feature of NN based model development. Training function ***'trainlm'*** was used to develop wheat yield prediction model. It is the fastest training function for the back-propagation algorithm in the NN toolbox software which updates weights and biases according to the Levenberg-Marquardt optimization [21]. The back-propagation algorithm is used to calculate the error between the output and target by randomly initializing the weight and biases for each neuron; then the weight will be updated until the network generalization stops as an indication of increase the mean square error of the validation sample. During the network training process, the data are randomly divided according to pre-specified percent, in this model for training 70% that are used to adjust the network according to its error, for validation 15% that are used to measure network generalization and stops training when generalization stops improving, for testing 15% are used to measure network performance. Every training attempt will produce completely different outcomes because of different initial conditions of weights and biases values and random sampling of data. The network is retrained when the first try did not generate desired results or need to improve the predicted results.

VI. Results and Discussion

The purpose of this model was to develop a satellite-based prediction model for predicting wheat yield in Bangladesh using the artificial neural network. We tested AVHRR-sensor derived vegetation health products VCI and TCI indices for wheat yield prediction six to eight weeks before harvest. The precision of this model was evaluated based on the Mean Square Error (MSE), regression values between actual and predicted data and prediction accuracy. The simulated results obtained from the model are illustrated in Tables 1 through 5. It was found that the model for 10 hidden neurons provided optimum performance.

a) Model Performance Evaluation

The model performance was evaluated by calculating the Mean Square Error (MSE), which is the average squared difference between the output (predicted) and targets (actual) for different hidden neurons. MSE is defined by the following equation, and the results for different hidden neurons are shown in Table 3.

$$F = MSE = \frac{1}{N}\sum_{i=1}^{N}(y_a - y_p)^2$$

Where N denotes the number of samples; for this study N is 22 (22 years from 1990-2011) shown in column 1, y_a represents the actual wheat yield statistical data shown in column 2, y_p represents the predicted (simulated) wheat yield shown in column 3-10 in Table 1, and e_y = (y_a - y_p) denotes the error between the actual and predicted wheat yield as shown in column 3-10 in Table 2. The performance (MSE) of the neural network for different hidden neurons shown in Table 3, it demonstrates that the best outcome (less MSE value) occurs for 10 neurons which were selected for our wheat yield prediction model. The model performance is reliable because the final MSE is very small. Fig. 4 shows the performance curve which is plotted between MSE and epochs for training, validation and test data set. It is seen that the best validation performance occurs at epoch 3 and training, validation and testing error all decreased until epoch 3, after that only training error decreases but validation and testing error increase until epoch 5, after that network training was stopped because network generalization stops improving, such as validation error increase which occurred after epoch 5. It does not appear that any overfitting had occurred since neither the validation nor testing error increased before epoch 3 where the best validation performance occurred.

© 2018 Global Journals

Table 1: Wheat Yield Statistical Data and ANN Model Predicted Yield Data for Different Hidden Neurons

Year	Actual/Target yield (Ton/Hectare)	Model output (prediction) for different no. of neurons (Ton/Hectare)							
		4	6	8	10	12	15	20	25
1988	1.7542								
1989	1.8246								
1990	1.5034	1.7802	1.5166	1.9362	1.4965	1.7520	1.5153	1.6129	1.9472
1991	1.6767	1.6806	1.5486	1.8474	1.6794	1.7285	1.6631	1.7947	1.6849
1992	1.8534	1.6951	1.5292	2.0497	1.8196	1.8934	1.8538	1.8220	1.8009
1993	1.8457	1.8443	1.5796	2.1140	1.8447	1.8469	1.8593	1.6893	1.7828
1994	1.8390	1.9142	1.7635	2.0322	1.8423	2.1320	2.1175	1.9430	2.2676
1995	1.9483	1.9035	1.9717	1.9596	1.9101	2.0457	2.0019	2.5071	1.9762
1996	1.9531	1.9733	1.9918	1.9199	1.9558	1.8544	1.9787	1.9369	2.2910
1997	2.0544	1.9723	2.1917	2.0840	2.0485	2.1589	2.0942	1.7950	1.9951
1998	2.2408	2.1989	2.1084	1.9152	2.1308	2.2660	2.2680	2.0155	2.0965
1999	2.1627	2.1214	1.8755	2.0933	2.1746	2.1670	1.6381	2.0801	2.2364
2000	2.2104	2.0434	1.9515	2.0406	2.0482	2.1870	2.2191	2.2084	2.1723
2001	2.1643	2.0971	2.1725	2.1424	2.2568	2.1267	2.2001	2.0227	2.0299
2002	2.1644	2.0702	1.7535	2.1669	2.1832	2.3149	2.2459	2.2901	2.1281
2003	2.1327	2.0644	2.1755	1.9896	2.141	2.0565	2.1589	2.0249	2.1487
2004	1.9527	1.9863	1.9084	2.0426	1.953	1.8946	1.9619	1.7711	1.9237
2005	1.7478	1.9059	1.5999	2.1310	1.7509	1.9259	1.7470	1.7390	1.7556
2006	1.5344	1.7583	1.4616	1.9529	1.532	1.8190	1.7903	1.4525	1.8878
2007	1.8471	1.7406	1.2239	1.7662	1.7306	1.6042	1.8666	1.2041	1.8411
2008	2.1753	1.7897	1.9408	2.2069	2.2457	2.0687	2.2180	2.0361	2.0611
2009	2.1516	2.1525	1.7584	2.1460	2.1468	1.8298	1.4462	2.0466	2.0964
2010	2.3959	2.4095	1.9181	2.2030	2.4046	2.0512	2.4147	2.1965	2.4166
2011	2.6012	2.2831	2.0304	2.5152	2.5856	2.5134	2.6263	2.3625	2.4391

Table 2: Wheat Yield Error of Prediction for Different Hidden Neurons

Year	Target/Actual yield (Ton/Hectare)	Model prediction error for different hidden layer neurons							
		4	6	8	10	12	15	20	25
1988	1.7542								
1989	1.8246								
1990	1.5034	-0.2768	-0.0132	-0.4328	0.0069	-0.2486	-0.0119	-0.1095	-0.4438
1991	1.6767	-0.0039	0.1281	-0.1707	-0.0027	-0.0518	0.0136	-0.1180	-0.0082
1992	1.8534	0.1583	0.3242	-0.1963	0.0338	-0.0400	-0.0004	0.0314	0.0525
1993	1.8457	0.0014	0.2661	-0.2683	0.001	-0.0012	-0.0136	0.1564	0.0629
1994	1.8390	-0.0752	0.0755	-0.1932	-0.0033	-0.2930	-0.2785	-0.1040	-0.4286
1995	1.9483	0.0448	-0.0234	-0.0113	0.0382	-0.0974	-0.0536	-0.5588	-0.0279
1996	1.9531	-0.0202	-0.0387	0.0332	-0.0027	0.0987	-0.0256	0.0162	-0.3379
1997	2.0544	0.0821	-0.1373	-0.0296	0.0059	-0.1045	-0.0398	0.2594	0.0593
1998	2.2408	0.0419	0.1324	0.3256	0.1100	-0.0252	-0.0272	0.2253	0.1443
1999	2.1627	0.0413	0.2872	0.0694	-0.0119	-0.0043	0.5246	0.0826	-0.0737
2000	2.2104	0.167	0.2589	0.1698	0.1622	0.0234	-0.0087	0.0020	0.0381
2001	2.1643	0.0672	-0.0082	0.0219	-0.0925	0.0376	-0.0358	0.1416	0.1344
2002	2.1644	0.0942	0.4109	-0.0025	-0.0188	-0.1505	-0.0815	-0.1257	0.0363
2003	2.1327	0.0683	-0.0428	0.1431	-0.0083	0.0762	-0.0262	0.1078	-0.0160
2004	1.9527	-0.0336	0.0443	-0.0899	-0.0003	0.0581	-0.0092	0.1816	0.0290
2005	1.7478	-0.1581	0.1479	-0.3832	-0.0031	-0.1781	0.0008	0.0088	-0.0078
2006	1.5344	-0.2239	0.0728	-0.4185	0.0024	-0.2846	-0.2559	0.0819	-0.3534
2007	1.8471	0.1065	0.6232	0.0809	0.1165	0.2429	-0.0195	0.6430	0.0060
2008	2.1753	0.3856	0.2345	-0.0316	-0.0704	0.1066	-0.0427	0.1392	0.1142
2009	2.1516	-0.0009	0.3932	0.0056	0.0048	0.3218	0.7054	0.1050	0.0552
2010	2.3959	-0.0136	0.4778	0.1929	-0.0087	0.3447	-0.0188	0.1994	-0.0207
2011	2.6012	0.3181	0.5708	0.0860	0.0156	0.0878	-0.0251	0.2387	0.1621

Table 3: The Performance (MSE) of ANN Model for Different Neurons in the Hidden Layer

NN Prediction Model performance	Neurons in the hidden Layer							
	4	6	8	10	12	15	20	25
MSE	0.0228	0.0790	0.0413	0.0062	0.0286	0.0424	0.0512	0.0328

© 2018 Global Journals

Table 4: Regression Performance of ANN Model for Different Neurons in the Hidden Layer

	Regression (R) value for different neurons in hidden layer							
	4	6	8	10	12	15	20	25
Training	0.91	0.77	0.79	0.99	0.88	0.99	0.88	0.97
Validation	0.96	0.95	0.83	0.96	0.83	0.69	0.91	0.82
Test	0.76	0.80	0.85	0.92	0.82	0.96	0.82	0.97
All	0.83	0.67	0.66	0.86	0.76	0.72	0.70	0.73

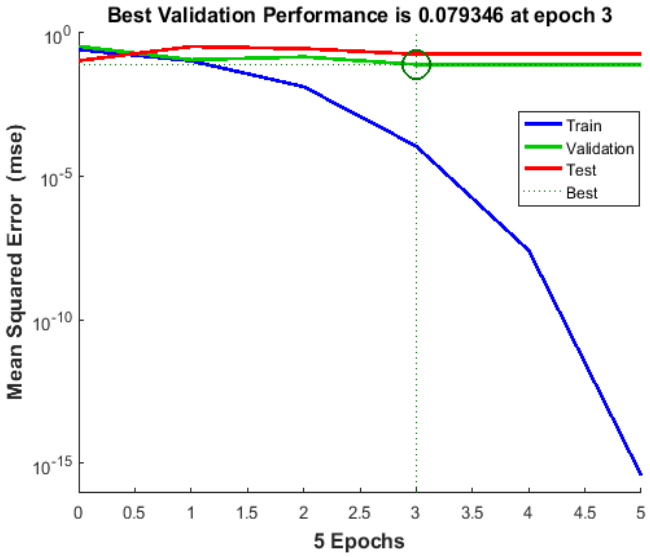


Fig. 4: Performance curve of NN with the best validation

b) Model Regression Evaluation

The correlation between wheat yield target and predicted data were determined by the regression value generated from the NN simulation shown in Table 4. It is seen that for our wheat yield prediction model there are strong correlations between the predicted and actual yield. The regression (R) value for training, validation and test dataset are greater than 0.92 and for all data response is 0.86 shown in Table 4. The regression value is a good indicator of the strength of the correlation between them. An R-value of 1 (one) indicates the best relationship and an R-value close to 0 (zero) indicates a random relationship. Regression plots for training, validation, testing and all data sets are demonstrated by four axes shown in Fig. 5. The dashed line in each plot represents the perfect correlation when the predicted yield is exactly equal to the target whereas the solid line represents the model's best fit between target and output. The regression plots depict that there are strong linear relationships between the predicted and the target data for all four situations. Therefore, it is proven that the ANN-based wheat yield prediction model is a successful model.

© 2018 Global Journals

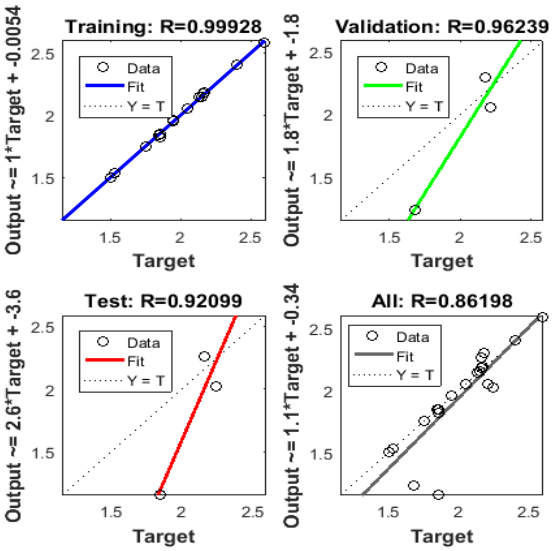


Fig. 5: Relationship between predicted (output) and actual (target) wheat yield data

c) Model Accuracy Evaluation

The reliability of the proposed wheat yield prediction model was assessed by comparing the target and output data. To determine the appropriate number of neurons for model development, we examined the ANN for different neurons in the hidden layer. We tested for 4, 6, 8, 10, 12, 15, 20 and 25 hidden neurons and computed the error of prediction to choose the proper hidden neurons to achieve optimum model performance. Based on the MSE and percentage error of prediction we selected 10 neurons for hidden layer because the model with 10 hidden neurons provides optimum performance in comparison to others. The accuracy of our proposed model was evaluated by calculating the percentage error of prediction using the following formula and the results are demonstrated in Table 5.

$$\%\ error = \frac{\text{Actual yield} - \text{Predicted yield}}{\text{Actual yield}} \times 100$$

From column 5 of Table 5, it can be seen that the model provides a high degree of accuracy because the percentage error of prediction for all 22 years from 1990-2011 are very reasonable. The minimum error is 0.0003 (0.02%), and the maximum error is 0.1622 (7.33%). Besides this, the error of prediction in each year is less than 8% and 91% of the errors of prediction is less than 5%. These explanations regarding model outcomes specify that our proposed wheat yield prediction model has a high level of accuracy in its capacity to predict wheat in Bangladesh. A comparison graph is plotted using actual and predicted wheat yield data to show the model accuracy in a more effective way is shown in Fig. 6. The graph indicates a high level of similarity between the actual and predicted yield. Thus, it can be said that the model is highly capable of predicting wheat yield in Bangladesh. Therefore, we can deduce that our ANN based prediction model, which uses satellite remote sensing data, is a reliable, accurate and highly promising wheat yield prediction model. Furthermore, this model can be used for other crops in Bangladesh to predict in the same fashion.

Table 5: Statistical Wheat Yield and Predicted Wheat Yield with the Error of Prediction in Bangladesh

Year	Target/Actual	Predicted	error	% of error
1988	1.7542			
1989	1.8246			
1990	1.5034	1.4965	0.0069	0.45%
1991	1.6767	1.6794	-0.0027	-0.16%
1992	1.8534	1.8196	0.0338	1.82%
1993	1.8457	1.8447	0.0010	0.05%
1994	1.8390	1.8423	-0.0033	-0.17%
1995	1.9483	1.9101	0.0382	1.96%
1996	1.9531	1.9558	-0.0027	-0.13%
1997	2.0544	2.0485	0.0059	0.28%
1998	2.2408	2.1308	0.1100	4.90%
1999	2.1627	2.1746	-0.0119	-0.55%

© 2018 Global Journals

2000	2.2104	2.0482	0.1622	7.33%
2001	2.1643	2.2568	-0.0925	-4.27%
2002	2.1644	2.1832	-0.0188	-0.86%
2003	2.1327	2.1410	-0.0083	-0.38%
2004	1.9527	1.9530	-0.0003	-0.02%
2005	1.7478	1.7509	-0.0031	-0.17%
2006	1.5344	1.5320	0.0024	0.15%
2007	1.8471	1.7306	0.1165	6.30%
2008	2.1753	2.2457	-0.0704	-3.23%
2009	2.1516	2.1468	0.0048	0.22%
2010	2.3959	2.4046	-0.0087	-0.36%
2011	2.6012	2.5856	0.0156	0.59%

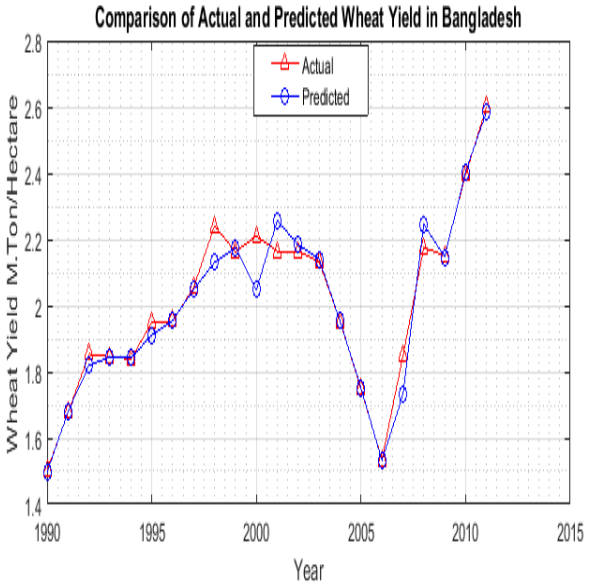


Fig. 6: Comparison graph of actual and predicted wheat yield in Bangladesh

VII. Conclusion

This study showed that wheat yield in Bangladesh could be predicted at approximately six to eight weeks before harvest time. The predicted yields are very close to the government-led statistical yields with an error of prediction less than 8%. Therefore, it is proven that AVHRR sensor based satellite data products vegetation health indices VCI and TCI characterizing moisture and thermal conditions respectively can be used as ideal predictors to predict wheat yield in Bangladesh. The study also showed that ANN is a potential tool for model development. We used the method of trial and error to select hidden layer neurons for developing an appropriate model, and it was found that the hidden layer with ten neurons produced the optimum result. It was observed that increasing the number of hidden neurons did not generate better outcomes. The methods and results of this model will serve as a prototype for other wheat-producing countries where remote sensing and historical data are available for use. The developed model has the ability for reliable, transparent and timely prediction of wheat yield in Bangladesh that can provide valuable information to the policymakers, government planners, agricultural stakeholders, researchers and any other concerned party.

References Références Referencias

1. Lucas, H., "The wheat initiative-an International Research Initiative for Wheat Improvement" 2nd Global Conference on Agricultural Research for Development, 29 Oct-1 Nov, 2012, Punta del Este, Uruguay.
2. Yearbook of Agricultural Statistics-2016. Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division, Ministry of Planning, Government of the people's republic of Bangladesh, www.bbs.gov.bd
3. Dempewolf, J., Adusei, B., Becker-Reshef, I., Barker, B., Potapov, P., Hansen, M. and Justice, C, "Wheat production forecasting for Pakistan from satellite data", IGARSS 2013 IEEE International Conference, Melbourne, Australia, 21-26 July, 2013, IEEE, DOI. 10.1109/GARSS.2013.6723517

© 2018 Global Journals

4. Alfares, H. K. and Nazeruddin, M. "Electric load forecasting: literature survey and classification of methods", International journal of system science, Vol.33, pp.23-34, 2002.
5. Cakir, Y., Kirci, M. and Gunes, E. O., "Yield prediction of wheat in south-east region of Turkey by using artificial neural networks", IEEE Agro-geoinformatics, 3rd International Conference on 11-14 August, 2014, Beijing, China, ISBN: 978-1-4799-4157-5.
6. Jiang, D., Yang, X., Clinton, N. and Wang, N., "An artificial neural network model for estimating crop yields using remotely sensed information", Int. J. Remote Sensing, Vol. 25(9), pp. 1723-1732, 2004.
7. Islam, A. K. and Bala, S. K., "Assessment of Potato Phenological Characteristics using MODIS-Derived NDVI and LAI Information," GIScience & Remote Sensing, Vol.45(4), pp.1-17, 2008.
8. Kogan, F.N., "Global drought watch from space," Bulletin of the American Meteorological Society, 78, pp. 621-636, 1997.
9. Rahman, A., Kogan, F., Roytman, L., "Analysis of malaria cases in Bangladesh with remote sensing data," Am. J. Trop. Med. Hyg., 74, pp.17–19, 2006.
10. Curtis, B.C., Rajaram, S. and Macpherson, H.G., "Bread Wheat Improvement and Production", FAO Plant production and protection series, No.30, pp.12-15, 2002.
11. Mandal, M.S.N., Pandit, D.B., Sufian, M.A., Mannan, M.A. and Hossain, A.K., "Problems and Prospects of wheat cultivation in Bangladesh", Int.J. BioRes., Vol.7(3), pp.45-52, 2009.
12. Rahman, M.A., Chikushi, J., Yoshida, S. and Karim, A.J., "Growth and yield components of wheat genotypes exposed to high temperature stress under control environment", Bangladesh J. Agril. Res., Vol.34(3), pp.361-372, 2009.
13. Shefali A. PRINCIPLES OF REMOTE SENSING. In *Satellite Remote Sensing and GIS Application in Agricultural Meteorology*, Proceedings of the training workshop, Dehra Dun, India, 7-11 July, 2003.
14. Atzberger, C., "Advances in Remote Sensing of Agriculture: Context Description, Existing Operational Monitoring Systems and Major Information Needs", Remote Sensing, Vol. 5, pp.949-981, 2013.
15. Kogan, F., Vargas, M., Ding, H. and Gui, W. "Vegetation Health Products (VHP) algorithm theoretical basis document" NOAA/NESDIS/STAR, Center for Satellite Applications and Research, Version 1.0, February 21, 2011.
16. Kogan, F.N., "Application of vegetation index and brightness temperature for drought detection," Adv. Space Res., Vol. 15(11), pp.91-100, 1995.
17. Kogan, F.N., "Operational space technology for global vegetation assessment," Bull Am. Meteorol. Soc., 82, 1949-1964, 2001.
18. Kogan, F., Stark, R., Gitelson, A., Jargalsaikhan, L., Dugrajav, C. and Tsooj, S., "Derivation of pasture biomass in Mongolia from AVHRR-based vegetation health indices," Int. J. Remote Sensing, Vol. 25, N. 14, p. 2889-2896, 2004.
19. Beale, M., Hagan, M. and Demuth, H., "Neural Network Toolbox™ Getting Started Guide," Matlab, Mathworks, R2017b.
20. Mohan, B.T., Vilas, N. G. and Prashant, P.B., "Hourly Load Forecasting Using Artificial Neural Network for a Small Area," IEEE-International Conference On Advances in Engineering, Science And Management (ICAESM-2012), 30-31 March, 2012, ISBN: 978-81-909042-2-3 @ 2012 IEEE.
21. Beale, M., Hagan, M. and Demuth, H., "Neural Network Toolbox™ User's Guide," Matlab, Mathworks, R2017b.

© 2018 Global Journals

This page is intentionally left blank

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Participatory Evaluation and Demonstration of Improved Forage Technologies under Small Scale Irrigated Condition in Amibara District of Afar Region

By Zeray Zeleke, Birhanu Megersa, Philimon Teshome & Tagel Alemu
Ethiopian Institute of Agricultural Research

Abstract- Participatory evaluation and demonstration of both grass and herbaceous legume forage crops namely Panicum antidotale, Rhodes grass, Cinchrus cilliaris and Medicago sativa and Dolichos lablab were undertaken under agro-pastoralist area under irrigated condition in middle awash irrigated area at farmers training centre during 2016 G.C. Agro-pastoralists PRG group formation and problem identification under taken prior to the implementation of demonstration activity. land preparation, sowing and overall husbandry was undertaken based on the agronomic recommendation so far developed by Werer Research Centre and the whole forage cultivation activity undertaken by the members of PRG. Variety evaluation in participatory way and organization of field days undertaken to collect the perception of agro-pastoralists towards the productivity of each forage crops and to create linkage for further adoption of the technology.

Keywords: pastoral research group, participatory variety evaluation, herbaceous grasses, herbaceous legumes.

GJSFR-D Classification: FOR Code: 079999

Strictly as per the compliance and regulations of:

© 2018. Zeray Zeleke, Birhanu Megersa, Philimon Teshome & Tagel Alemu. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Participatory Evaluation and Demonstration of Improved Forage Technologies under Small Scale Irrigated Condition in Amibara District of Afar Region

Zeray Zeleke [α], Birhanu Megersa [σ], Philimon Teshome [ρ] & Tagel Alemu [ω]

Abstract- Participatory evaluation and demonstration of both grass and herbaceous legume forage crops namely Panicum antidotale, Rhodes grass, Cinchrus cilliaris and Medicago sativa and Dolichos lablab were undertaken under agro-pastoralist area under irrigated condition in middle awash irrigated area at farmers training centre during 2016 G.C. Agro-pastoralists PRG group formation and problem identification under taken prior to the implementation of demonstration activity. land preparation, sowing and overall husbandry was undertaken based on the agronomic recommendation so far developed by Werer Research Centre and the whole forage cultivation activity undertaken by the members of PRG. Variety evaluation in participatory way and organization of field days undertaken to collect the perception of agro-pastoralists towards the productivity of each forage crops and to create linkage for further adoption of the technology. From herbaceous grasses panicum antidotale is found to be better in plant height, early maturity and higher fresh and dry matter yield. Rhodes grass is found to be late in maturity but with better biomass yield followed by panicum antidotal but cinchrus cilliaris is found to be tolerant to stress but with lower dry matter. From herbaceous legumes dolichos lablab is found to be superior in early maturing and biomass yield however due to the possibility of multiple harvest from Medicago sativa the annual biomass yield and cost of production is found to better for Medicago sativa. Agro-pastoral perception collected indicated that among the tested forage varieties from grasses interms of biomass yield, early maturing, leaf to stem ratio, ease of establishment, multiple harvest and nature of purpose as well a resistance to stress Panicum ranked first followed by rhodes there by cinchrus species, from leguminous species Dolichos lablab is found to be better in most of agro-pastoralists evaluation criteria but due to the possibility of multiple harvest without replanting and due to feed preference from domestic animals Medicago sativa is found to be superior feed and selected as best forage crop. From the above participatory variety evaluation work it's found that most of the parameters agro-pastoralists use to select variety have similarity with scientific criteria.

Keywords: pastoral research group, participatory variety evaluation, herbaceous grasses, herbaceous legumes.

Author α σ ρ ω: Ethiopian Institute of Agricultural Research, Werer Research Center, Ethiopia. e-mails: brmeg1900@gmail.com, zzeleke@gmail.com, zphili@gmail.com

I. Introduction

Pastoral areas in Ethiopia, cover about 0.7 million square km, support about 9.8 million people (12% of the total population) of which 56 % are pastorals, 32% are agro-pastorals and the remaining 22% are urban dwellers (EEA, 2005). Another report shows that, pastoral communities occupied about 63% of the country's land mass (MoARD, 2008). Although pastoralism plays significant role in the Ethiopian economy and provides social and environmental integrity in the lowlands, the sector has been largely marginalized by development policies and strategies in the past.

Afar Region covers 10% of the total area of the country and 29% of the pastoral lowlands (Yirgalem, 2011). Though most of the region is arid and semi-arid, it was possible to support the population of Afar pastoralists for centuries mainly due to the presence of extended rangelands and perennial rivers including the profound Awash River, which is the life-belt of Afar communities and their livestock. However, with increasing human population and environmental problems (including frequent drought and degradation of rangelands), the situation has changed the other way through time causing declining production and productivity of food and feed in the region. On the other hand, most of the large-scale irrigation farms and subsistence irrigated crop cultivation have continued to grow from time to time due to the presence of Awash and other rivers in the region. It also created an increasing demand of pastoralists and agro-pastoralist to be involved in irrigated cultivated crop, forage and pasture production.

The traditional Afar pastoral system involves mobility between dry and wet season pastures within a radius of approximately 50 kilometers (Yacob et al., 2009). However, over the past decades this pattern of mobility in particular and the Afar subsistence pastoral system in general have been under pressure due to various socio-economic and other internal and external factors. These factors include recurrent drought and famine, flash floods, disease outbreaks, bush

© 2018 Global Journals

encroachment, loss of livestock, pastoral conflict and population growth. Moreover, climate change added new and largely uncertain dimension to existing development problems by compounding the risks of natural hazards and complicating existing social and economic imbalances. It is widely recognized that failure to respond to these challenges would impede efforts aimed at reducing pastoral poverty and insecurity (EPA, 2010).

Given the impact of socio-economic and other internal and external factors including climate change on the highly livestock dependent pastoral communities; diversifying livelihood and practicing alternative options is becoming a question of survival than choice. Because livelihood diversification builds household's resilience through risk spreading (EPA, 2010). Pastoralists can diversify their livelihood by engaging in any income generating activities such ascultivation. Therefore, enhancing and securing pastoralists' access to strategic resources like agricultural technology is basic and essential if they are to adequately prepare and effectively respond to the multitudes of stresses and challenges they face.

In the past, pastoral community's temporal and spatial mobility coupled with poor linkage among relevant stakeholders have been the bottleneck for undertaking a coordinated intervention targeted in enhancing the community's access to improved agricultural technologies and management practices, but recently the transition of pastoralists to agro-pastoralists created an opportunity. Hence, livelihood diversification interventions such as expansion of opportunistic and irrigated crop production activities are critically important in these areas there by to improve the feed and food security and income of settled agro-pastoral households and to improve their resilience to different shocks. These in turn demand all relevant stakeholders, which are important along the value chain of agricultural technology generation and dissemination, to intervene in partnership. By this it is possible to enhance agro-pastoralists' access to improved agricultural technologies and management practices thereby to improve production and productivity, livestock feed availability and food security situations in the area.

a) Purpose

The overall purpose of this participatory research activity is to conduct joint experimentation and evaluation of forage grasses and legume varieties and introduce best bit forage technologies to agro-pastoralists. The intervention can benefit agro-pastoralists with improved availability and access to forage varieties based on their needs. The joint experimentation and evaluation can build up the capacity of the community in feed and forage seed production techniques by participating farmers in the research activities, giving training on forage production and arranged field visit on farmers forage production fields. The feedback from this project will benefit the national and regional participatory forage feed and seed research and technology dissemination process. It will also provide direct information to the participatory forage variety technology transfer process by highlighting promising varieties that address the needs of livestock farming and agricultural communities.

b) Objectives

i. *General objective*

Is to identify varieties that meet the needs of pastoralists and improve adoption of forage crop technologies in pastoral and agro-pastoral areas.

ii. *Specific objective*

- To demonstrate and evaluate the performance of improved forage varieties with the participation of pastoralists and agro-pastoralists in middle awash irrigated areas
- To introduce feed crop production scheme to the area and enhance livestock productivity.
- To develop varieties that best meets the needs and demand of pastoral and agro-pastoral communities
- Create new and strengthen exiting linkages and partnership among concerned stakeholders for enhanced technology transfer
- To improve the know-how and skill of agro-pastoralists, DAs and agricultural experts with regard to improved forage production and management practices
- To develop and document base line information for further research and development on participatory forage evaluation

II. Methodology

a) Description of study sites

This particular participatory research project has conducted in Amibara district which is found in Afar Regional States. Amibara district is situated in Zone Three of Afar Regional State along the Awash River in the North Eastern part of Ethiopia. Amibara which is one of the six districts of Zone three and has nineteen kebeles. In terms of geographical reference, the district is located between 09'N to 10'N and 39'45 E to 40'30 E longitude covering a total area of 925,450 hectare (Getachew, 2001). The average altitude of the district is 740m.a.s.l. with mean annual temperature of 34.10C. The rainfall distribution varies from year to year, but the average mean annual rainfall is about 575 mm. In general, arid and semi-arid climatic environment is the typical characteristics of the district (Getachew, 2001).

The total population of the district is 63,280 of which, 44 % are women. The rural population of the district is 31,194 of which 43.3 % are women. About 91 % of the population lives in rural areas. The district is inhabited by both Afar and non-Afar. The non-Afar are

© 2018 Global Journals

mainly highlanders who came after the introduction of irrigated agriculture in the 1960s. The livelihood of the district largely depends on traditional pastoralism with seasonal movement of people and livestock to other areas in search of water and forage.

The district is one of the richest areas of the region with fertile arable land, huge livestock number, tourist destinations and some mineral resources. The area is mostly known for large scale irrigated cotton plantation schemes. These private and state farm schemes make the area one of the major cotton producing locations in the country. It is suitable to grow different crops and vegetables all year round using the perennial Awash River (Ali, 1997). Moreover, the area is accessible to regional and external markets, as it is found 250 km from Addis Ababa on the main road to Djibouti port. And this particular research has been conducted at farmers training centre at Ambash kebele.

b) Participant selection and experimental procedure

WARC jointly with Zonal MST and Woreda Project Office as well as district PADO identified intervention kebeles and from selected kebeles a PRG which comprises of 25 members inclusive of women's formed. Discussion forums organized, problem identification and ranking undertaken in participatory way. Based on the identified problems possible interventions identified. Among the problems identified feed shortage and lack of skills in production of high yielding improved forage crops husbandry are the high ranking.

Five forage crop varieties that was recommended by Werer Research Centre for irrigated area of Afar namely Panicum antidotal, Rhodes grass, Cinchrus cilliaris, Alfalfa and Dolichos Lablab have been selected and used as an experimental crop. Prior to the implementation of demonstration and participatory variety evaluation practical training organized and all PRG members trained on forage husbandry. The land which is labeled and access to irrigation water over the year has been selected inside the FTC found in the intervention kebele. the land which is enough to accommodate 10m*10m for five crops having three replication each identified and ready for sowing and the Randomized complete block design has been used as an experimental design.

Land preparation, sowing and irrigation was undertaken by members of the PRG based on the agronomic recommendation of each forage crops. Based on this the spacing of 40cm distance between rows for Panicum, Rhodes, Cinchrus, Alfalfa, and Dolichos lablab is used. Spacing between seeds were 10cm for dolichos lablab and no spacing for other feed crops. Seeding rate for each experimental crop is 10kg/ha for Rhodes and cinchrus spp, 5 kg/ha for Panicum, 8kg/ha for Alfalfa, and 20kg/ha for lablab. Prior to well establishment irrigation frequency of 5to7 days used and after well establishment 15 days irrigation frequency was practiced for all crops. Other agronomic practices like weeding, pest management and other related activities also considered as a routine activity during experimental period.

Data collection was undertaken for planting date, germination date, irrigation frequency, tolerance (pest and water stress), days to maturity, leaf to stem ratio, biomass yield for both fresh and dry matter and seed yield as well as preference/selection ranking undertaken by the participating agro-pastoralists. Half of the plot (5m*10m) has been used to collect the above data's and the remaining half plots used to collect seed yield. Biomass sampling was undertaken using 1m * 1m quadrants, 300gm sample taken randomly, oven drying undertaken at 62 degree celsius for 72 hours.

© 2018 Global Journals

Fig. 1: Field Status of Forage Demonastration Site in Pastoralists Plot

III. Result and Discussion

a) Herbage yield, plant height and maturity date

i. *Grass*

In forage research, variety development and feed production more than the grain much emphasis is given to the herbage yield. As indicated at table1 36 to 42 tone (36,000kg to 42,000 kg) fresh biomass was obtained from a single harvest. From this demonstration and participatory variety trial its observed that statistically insignificant yield difference was obtained from chloris gayana (Rhodes grass) and panicum antidotale (Blue panic) 10.44 and 10.37 respectively whereas the dry matter yield of cinchrus cilliaris is statistically significantly lower than other intervention grasses. Because of the possibility of multiple harvest from those perennial grasses it was possible to have 5, 6 and 7 times harvest from chloris, cinchrus and panicum respectively. Plants height is one of the factor that can influence the herbage yield of forage species, plant height measurement result indicated that panicum antidotale registered maximum height as compared to other species but the result is found to be statistically insignificant as compared to chloris gayana but both grasses are significantly different from cinchrus cilliaris. The data collected on optimum harvesting date indicated that chloris gayana and cinchrus cilliaris attain physiological maturity at 78 and 73 days which is significantly late than that of Panicum Antidotale is 61 days after sowing.

Table 1: Agronomic Characteristics of Forage Crops (Grasses)

Variety	Plant Height (meter)	Date to physiological maturity	Fresh biomass yield (ton/ha)	DM yield ton/ha/harvest	DM yield ton/ha/year	Remark
Chloris gayana	1.92a	78a	36,2c	10.44b	52bc	5*10.4=52
Cenchrus cilliaris	1.34c	73ab	36,6bc	8.12c	48.72c	6*8.12=48.72
Panicum Antidotale	2.03ab	61c	42,7a	10.37ab	72.59a	7*10.37=72.59
LSD 0.05	24	8.73	3,63	1.13	12.9	

ii. *Herbaceous legumes*

Agronomic result summarized at table 2 indicated that for non grass herbaceous layer called medicago sativa and dolichos lablab showed that 37 to 44 tone of fresh biomass has been obtained from single harvest. Dolichos lablab showed statistically significantly better biomass yield as compared to Medics. Past research result indicated that species like Medics are naturally perennials and they can produce much more biomass than Dolichos lablab due to the possibility of multiple harvest. Data obtained from WARC and summarized at table 2 indicated that up to 68 tone dry matter can be obtained from 8harvest per year per hectar for medics without any new seed sowing which is statistically significant. However dolichos lablab needs sowing seeds after harvest and maximum of three

© 2018 Global Journals

harvest per year is possible. Plant height measurement result indicated that dolichos is superior in height than medics. Date to first physiological maturity indicated that dolichos needs less date to attain physiological maturity than medics.

Table 2: Agronomic Characteristics of Forage Crops (Herbaceous legumes)

Variety	Plant Height	Date to first physiological maturity	Fresh biomass yield (ton/ha/harvest)	DM yield ton/ha/harvest	DM yield ton/ha/year	Remark
Medicago sativa	69.3b	67b	37.29b	8.5b	68a	8*8.5=68
Dolichos Lablab	183.2a	61a	44.12a	15.2a	60.8b	4*15.2=60.8
LSD 0.05	80.5	4.2	4.8	5.7	6.7	

LSD= least significant difference, DM= dry matter, kg= kilogram, ha= hectar
Note= values assigned with the same letter will be statistically not different from each other

b) Seed yield and Germination Rate of collected seeds

Quality seed is the base for successful adoption of any agricultural crop technology. Various survey result indicated that quality seed as well in quantity is the major drawback for the low adoption rate of forage technologies. During this participatory variety evaluation and demonstration, forage seed production was demonstrated successfully to agro-pastoralists result summarized at table 3 indicated that maximum seed of 491kg per hectare was obtained from panicum antidotale followed by chloris gayyana, cenchrus cilliaris and medics which is 362.9, 279 and 167kg/ha respectively. Seed germinability is the major variable in measuring quality seed, most of forage grasses needs some time to break dormancy. Previous research conducted at werer research centre indicated that storage of grass seeds for 12 month will result in better germination than using immediately after harvest. In this participatory evaluation seeds collected and stored for six month tested for germinability and its found that 42 to 87 percent germination of seeds has been obtained. Panicum and medics registered better germination percentage than chloris gayana and cinchrus cilliaris which is 87, 63.3, 47.5 and 42.2 respectively for medics, panicum, chloris and cinchrus. Herbage yield after seed harvest collected indicated that there is a significant decline in yield except chloris gayana as compared to the herbage yield collected at optimum physiological stage summarized at table 1. Various research so far undertaken indicated that the quality of feeds will decline with the increase in the age of the crop and panicum antidotale and cinchrus cilliaris affected significantly since the new tillering from established crop is uncommon. Whereas other forage crops chloris gayana and medics will produce new tillers the biomass yield doesn't affected significantly. From this result its understood that integrating seed and herbage production is possible for chloris gayana and medicago sativa without compromising the biomass yield than other crops. The seed yield data for chloris gayana was not produced due to the photo periodic nature of the crop during the experimental period.

Table 3: Seed related characteristics of forage crops

Variety	Number of plant per quadrant (1m*1m)	Harvesting date after flowering	Seed Yield kg/ha/harvest	Germination percentage at 6 month	DM Yd ton/ha/year during seed harvest	Remark
Chloris gayana	178	40	362.9	47.5	48	
Cenchrus cilliaris	287	29	279	42.2	42.14	
Panicum Antidotale	213	33	491	63.3	57.23	
Medicago sativa	472	52	167	87	62	
Mean	**287.5**	**38.5**	**324.9**	**60**	**52.3**	

c) Agro-pastoralists forage evaluation and selection

i. *Grasses*

As indicated at table 4 agro-pastoralists identified 11 criteria for evaluation and ranking of forage crops. Accordingly date to maturity Panicum Antidotale is found to be early in attaining maturity followed by cinchrus cilliaris and chloris gayana. Agro-pastoralists indicated that less maturity date will help them to get biomass with less irrigation frequency which can help them to save irrigated water. Interms of biomass productivity panicum antidole selected as best yielder against other forage crops but the result obtained and summarized on ***Table 1*** indicated that rhodes grass is superior in biomass productivity than cinchrus cilliaris

© 2018 Global Journals

but participants selected cinchrus as superior to chloris, probabily this may related to the growth nature of those crops. Purpose of the crop is the other evaluation criteria agro-pastoralists used for ranking the forage crops in addition to feeding animals thachability of the grass is used as an additional benefit for this Panicum Antidotale and cinchrus cilliaris is found to be better than chloris gayana. Interms of seed production capacity participants percieve that panicum yields high seed and chloris gayana and cinchrus cilliaris is found to be similar. But the data collected and summarized at table 3 indicated that chloris superior to cinchrus interms of seed yield, this might be related with the seed production nature of both species since chloris produces seed gradually as compared to cinchrus cilliaris. panicum is found to be better in estabilishment, number of harvest per year, seed benefit, and storage space requirement and but cinchrus is better in resistance to stress than other crops and finaly agro-pastoralists identified that by various selection criteria panicum antidotale is found superior followed by cinchrus cilliaris and chloris gayana. Previous onstation experiment result indicated that panicum and chloris are among the high ranking by various measurement variables against cinchrus cilliaris.

Table 4: Agro-pastoralists preference towards the performance of forage grasses

Variety Selection Criteria	Variety		
	Chloris gayana (Rhodes grass)	Cenchrus cilliaris (Buffle grass)	Panicum Antidotale (Blue panic)
Early maturing	3rd	2nd	1st
Biomass yield	3rd	2nd	1st
Purpose (Dual or mono purpose)	2nd	1st	1st
Seed yield	2nd	2nd	1st
Ease of establishment	3rd	2nd	1st
Intake by animals	1st	3rd	2nd
Repeated harvest (no of harvest/year)	3rd	2nd	1st
Leaf to stem ratio	1st	3rd	2nd
Benefit from seed	2nd	3rd	1st
Resistance to stress	3rd	1st	2nd
Storability	2nd	3rd	1st
Rank	3rd	2nd	1st

ii. *Herbaceous legumes*

Agro-pastoralists late to evaluate forage legumes developed various selection criteria's. based on the selection criteria interms of biomass productivity, multiple purpose, livestock preference, possibility of multiple harvest and leafyness, medicago sativa is found to be superior to dolichos lablab. whereas due to early maturing nature and ease of establishment doclichos lablab is found to be superior to medicago sativa. Agro-pastoralists decided to evaluate the leguminous forage crops for the storability, resistance to stress as very good, good and bad based on this dolichos lablab storability is found to be poor whereas resistance to stress and disease dolichos is found better than medics. Based on this agro-pastoralists identified that medicago sativa is superior to dolichos lablab by various evaluation criteria.

Table 5: Agro-pastoralists preference towards the performance of herbaceous legumes

Variety Selection Criteria	Variety	
	Medicago Sativa Alfalfa)	Dolichos Lablab (Lablab)
Early maturing	2nd	1st
Biomass yield	1st	2nd
Purpose (Dual or mono purpose)	1st	2nd
Ease of establishment	2nd	1st
Intake by animals	1st	2nd
Repeated harvest (no of harvest/year)	1st	2nd
Leafy nature	1st	2nd
Storability	Good	Poor
Resistance to disease stress	Good	V. good
Resistance to water stress	V. good	V. good
Rank	1st	2nd

© 2018 Global Journals

IV. Conclusion

The following lessons were drawn from the experience with forage technology participatory evaluation using PRGs:

- Improved research-extension-agro-pastoralists linkage at the grass root level
- Improved stakeholders' participation in research and extension activities
- The approach was found best for identification of adaptable, high yielder and disease tolerant or resistant varieties by the clients themselves using indigenous variety selection criteria
- The approach was found efficient and effective in addressing research and technology extension issues since it utilizes both scientific and indigenous knowledge systems
- The approach helped in developing sense of ownership technology development activities
- The approach provided the means for feedback on technologies generated and disseminated

It's found that the PRG are effective and efficient approaches in generating, evaluating and disseminating forage technologies. Werer agricultural research centre used this approaches as means to address the week technology adoption of the various forage technologies so far developed. The valuable contribution of these approaches towards the realization of the goals of the centre is well acknowledged and appreciated.

Acknowledgments

We are extremely thankful to the Pastoral Community Development Project(PCDP),for financial support and Werer Agricultural Research Center for Research material and vehicle support. Finally, we are grateful acknowledged the Amibara Woreda Pastoral and Agricultural Development Office and extension developmental agents for their continuous monitoring the experimental site and our pastoralists who donated their land and labour without restraint.

References Références Referencias

1. Cook, B.G., Pengelly, B.C., Brown, S.D., Donnelly, J.L., Eagles, D.A., Franco, M.A., Hanson, J., Mullen, B.F., Partridge, I.J., Peters, M. and Schultze-Kraft, R. 2005. Tropical Forages: an interactive selection tool., [CD-ROM], CSIRO, DPI&F(Qld), CIAT and ILRI, Brisbane, Australia.
2. Denbela Hidosa, Bizuayehu Ayele and Mesifin Mengistu (2015). Participatory On - Farm Evaluation and demonstration of improved Legume Forage Species in Benatsemay Woreda of South Omo Zone, Southern Agricultural Research Institute, Jinka Agricultural Research Center, P. O. Box 96 Jinka, Ethiopia.
3. Denbela Hidosa, Tekleyohanus Brehanu and Mesfin Mengitu (2016). On Farm Evaluation and Demonstration of Improved Legume forage Species in Irrigated Lowlands of Bena-Tsemay Woreda, SouthOmo Zone, International Journal of Research and Innovations in Earth Science Volume 3, Issue 2, ISSN (Online): 2394-1375.
4. ESGPIP (Ethiopia Sheep and Goat Productivity Improvement Program), 2008. Technical Bulletin No. 17. Fodder Establishment, Management and Utilization Techniques for the smallholder.
5. Funk, Rowland, Eilerts, Kebebe E, Biru et al. (2012) Climate trend analysis of Ethiopia. Climate change adaptation series. U.S. Geological survey famine early warning systems Network-Informing (FEWSNET) Fact sheet 3053. p. 6.
6. Ibrahim, Truong Tan Khanh and Heriyanto. 2000. Forage technologies for smallholders in grassland areas. In: Stür, W.W., Horne, P.M., Hacker, J.B. and Kerridge, P.C. ed. Working with Farmers: the Key to Adoption of Forage Technologies. These Proceedings, see Contents.
7. Norton (1982) Differences between species in forage quality. In: Hacker JB (eds), Nutritional limits to animal production from pastures. Farnham Royal: Commonwealth Agricultural Bureaux. pp 89–110.
8. Stür, W.W., Cameron, A.G. and Hacker, J.B. 1995. Forages for Smallholders – Proceedings of the Third Meeting of the Southeast Asian Forage Seeds Project, Samarinda, Indonesia, 23–28 October 1994. CIAT Working Document No. 143. Cali, Colombia, CIAT, 149 p.
9. Tessema Zewdu .2008. The Effect of Variable Seed Rate Proportions on Agronomic Attributes, Dry Matter Production, Biological Potential and Economic Viability of Some Grass-Legume Mixed Pastures.
10. Tollefson, L. and Wahab, 1. 1996. Better research-extension-farmer interaction can improve the impact of irrigation scheduling techniques. In: Irrigation Scheduling from Theory to Practice. Proceedings of the ICIDIFAO Workshop on Irrigation Scheduling. FAO Publication 8, Water Reports. Rome, Italy. pp. 227-234.
11. Vermillion, D. L. and Brewer, J.D. 1996. Participatory action research to improve irrigation operations: examples Jrom Indonesia and India. In: Irrigation Scheduling: From Theory to Practice. Proceedings of the ICIDIFAO Workshop on Irrigation Scheduling. FAO Publication 8, Water Reports. Rome, Italy. pp. 227-234

© 2018 Global Journals

This page is intentionally left blank

Early View

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Assessment of Entomocidal Effects of Solar Radiation for the Management of Cowpea Seed Beetle, *Callosobruchus Maculatus* (F.) (Coleoptera: Chrysomelidae) in Stored Cowpea

By Adebayo, R. A. & Anjorin, O. O.
Federal University of Technology

Abstract- Cowpea seed beetle, *Callosobruchus maculatus* (F.) is a major pest of cowpea, *Vigna unguiculata* (L.) Walp. in the tropics and subtropics. It causes remarkable quantitative and qualitative losses to stored cowpea in these regions. Therefore, an experiment to investigate the entomocidal effects of solar radiation for the management of *C. maculatus* was conducted in the laboratory of the Department of Crop, Soil and Pest Management, Federal University of Technology Akure. Twenty seeds of Oloyin cowpea were infested with freshly emerged adults of *C. maculatus* in Petri dishes replicated three times. Petri dishes and their contents were exposed to solar radiation for 1, 2 and 3 hours and subsequently removed from sun. They were left in the laboratory for the adult emergence. The results indicated that the different biological parameters studied were significantly ($p<0.05$) affected when the insects were exposed to solar radiations. The exposure to solar radiation significantly caused mortality, inhibits egg laying, embryonic development of *C. maculatus* resulting in inhibition of the emergence of the offspring. Thus, solar radiation could be an effective method for post-harvest management of cowpea seed beetle, *C. maculatus* to prevent damage during cowpea storage.

Keywords: *entomocidal, solar radiation, assessment, callosobruchus maculates.*

GJSFR-D Classification: *FOR Code: 079999*

ASSESSMENTOFENTOMOCIDALEFFECTSOFSOLARRADIATIONFORTHEMANAGEMENTOFCOWPEASEEDBEETLECALLOSOBRUCHUSMACULATUSFCOLEOPTERACHRYSOMELIDAEINSTOREDCOWPEA

Strictly as per the compliance and regulations of:

Research | Diversity | Ethics

© 2018. Adebayo, R. A. & Anjorin, O. O. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Assessment of Entomocidal Effects of Solar Radiation for the Management of Cowpea Seed Beetle, *Callosobruchus Maculatus* (F.) (Coleoptera: Chrysomelidae) in Stored Cowpea

Adebayo, R. A. [α] & Anjorin, O. O. [σ]

Abstract- Cowpea seed beetle, *Callosobruchus maculatus* (F.) is a major pest of cowpea, *Vigna unguiculata* (L.) Walp. in the tropics and subtropics. It causes remarkable quantitative and qualitative losses to stored cowpea in these regions. Therefore, an experiment to investigate the entomocidal effects of solar radiation for the management of *C. maculatus* was conducted in the laboratory of the Department of Crop, Soil and Pest Management, Federal University of Technology Akure. Twenty seeds of Oloyin cowpea were infested with freshly emerged adults of *C. maculatus* in Petri dishes replicated three times. Petri dishes and their contents were exposed to solar radiation for 1, 2 and 3 hours and subsequently removed from sun. They were left in the laboratory for the adult emergence. The results indicated that the different biological parameters studied were significantly ($p<0.05$) affected when the insects were exposed to solar radiations. The exposure to solar radiation significantly caused mortality, inhibits egg laying, embryonic development of *C. maculatus* resulting in inhibition of the emergence of the offspring. Thus, solar radiation could be an effective method for post-harvest management of cowpea seed beetle, *C. maculatus* to prevent damage during cowpea storage.

Keywords: entomocidal, solar radiation, assessment, callosobruchus maculatus.

I. Introduction

Cowpea, *Vigna unguiculata* (L.) Walp. is an important grain legume gown mostly in the dry Savannah of the tropics in an estimated area of 12.5 million hectares with annual production of about 3.3 million tons (FAO, 2005). Nigeria is the world's largest producer with 2.1 million ton (IITA, 2000). It is a source of income for many smallholder farmers and contributes to the sustainability of cropping system and soil fertility improvement in marginal lands through provision of ground cover and plant residue, nitrogen fixation and suppression of weeds (Sanginga *et al.,* 2003. Cowpea is a food legumes widely cultivated in the world with an estimated 3.3 million tons of dry seeds of which 64%are produced in Africa. The worldwide-cultivated area is estimated to be more than 12.5 million hectares annually, with about 9.8 million hectares in West Africa. This region is therefore the largest producer and consumer of cowpea in the world.

Production of this important crop has been constrained by insect pests among other factors (Adedire, 2001). However, post-harvest losses of cowpea grain are a serious problem, and in Africa, as much as 20-50% of grain is lost because of infestation from pest. Infestation results into weight loss and quality deterioration and the growth of moulds (Adebayo and Hassan, 2017). This renders cowpea grain unfit for consumption and selling. Thus, farmers are forced to sell their products early after harvest when prices are still low partly because of anticipated losses in storage. Cowpea infestation by cowpea bruchids, *Callosobruchus maculatus* starts in the field and continues in storage. Bruchid are minor pests in the field which assume a major pest status during storage (Ofuya and Bamigbola, 1991; Adebayo, 2015). It is a cosmopolitan field-to-store pest of cowpea which causes substantial quantitative and qualitative losses manifested by seed perforation and reduction in weight, market value and germinability of seeds (Ogunwolu and Odunlami, 1996; Adeduntan and Ofuya, 1998; Ofuya, 2003). A substantial loss of about 30-80 percent of the total annual production of cowpea valued at over 30 million US dollars is lost annually in Nigeria alone to this bruchid.

Being a major pest of cowpea, black grams (*Mungo hepper*) and other grain legumes, the spotted cowpea weevil, *Callosobruchus maculatus* (F) is an important pest of pulses in Africa and tropical Asia both in field crops and in stores (Hill,1990). The pest causes damage only at immature stages because the adults normally do not feed in the granaries (Fox *et al.,* 2004; Olotuah *et al*., 2007). Under traditional storage conditions, 100% infestation of cowpea occurring within 3 to 5 month of storage is common (Caswell & Akibu, 1980). It causes substantial qualitative and quantitative losses manifested by seed perforation, reduction in weight, market value and germinability of seeds (Anonymous, 1989; Ofuya, 2003). In the recent past, the control of insects and other storage pest was basically

Author α σ: Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, Federal University of Technology, P. M. B. 704, Akure, Nigeria.
e-mails: raphael.adebayo@yahoo.com, raadebayo@futa.edu.ng

© 2018 Global Journals

through the use of chemical methods comprising fumigation of stored commodity with carbon disulphide, phosphine or dusting with malathion, carbarly, pirimiphos-methyl or permethrin. These chemicals have been reported to be effective against *C. maculatus* and other insect pests (Akinkurolere *et al.,* 2006). However, the problems of many synthetic insecticides which include: high persistence, poor knowledge of application by resource-poor farmers, high cost, non-availability, genetic resistance and hazards to environment and human health have necessitated the search for relatively cheap, environmental safe and sustainable control measures (Akinkurolere *et al.,* 2006). As part of the quest for an alternative to chemical insecticides, research efforts are currently being focused on eco-friendly control measures such as irradiation, heat treatment, bio-pesticides, integrated pest management, use of insect hormones (Begum *et al.,* 1991; Follet *et al.,* 2007).

Solar heating of cowpeas is one of the alternatives, less hazardous and safe methods to control *C. maculatus*. Eggs deposited on the surface of the seeds exposed to high temperature and low humidity conditions will dry out. Furthermore, the eggs, larvae and pupa being immobile, are unable to escape from the hot environment. Therefore, bruchids living within grain are excellent targets for management using elevated temperature (Murdock *et al.,* 1991). Farmers in many parts of the tropics are already using solar heat as a means of driving out insects from infested grains and, perhaps, in an attempt to kill any larvae which may be inside the grains (McFarlane, 1977). The effectiveness of the technique depends upon spreading the grains in thin layer and exposing them to the sun for a long period. Solar disinfestations technology is an effective, low cost, non-toxic pest control process, which does not alter the physical, cooking, nutritive, and other desirable properties of the cowpea grain (Nyankori, 2002). Exposing threshed cowpea to solar radiation on a simple solar heater developed at Purdue (USA) and tested in Cameroon can kill within minutes, resident infestation of cowpea weevils in grain. This technique has already undergone testing and extension in Cameroon and many West African countries, namely, Burkina Faso, Mali, Nigeria, Chad, Benin and Ghana (Ntoukam *et al.,* 2000). Therefore, this study assessed the entomocidal effects of solar radiation in the management of cowpea seed beetles, *C. maculatus.*

II. Materials and Methods

a) Study site

The experiments were conducted at the laboratory of the Department of Crop, Soil, Pest Management, Federal University of Technology, Akure, Ondo State, Nigeria under the ambient laboratory conditions of 26-28°C temperature and 60-75% relative humidity.

b) Collection of materials and culturing of C. maculatus

Clean uninfested seeds of Oloyin cowpea were purchased from Isinkan market in Akure, Ondo State while the stock culture of *Callosobruchus maculatus* was established using adults derived from infested beans seeds (Oloyin) obtained from the Oba market in Akure. Insects were reared on susceptible wholesome seeds (Oloyin) kept in plastic containers covered with muslin cloth held in place with tight rubber bands. The culture was maintained under laboratory conditions (28±2°C, 70-75% RH). Healthy 24-48 hours old adult's *C. maculatus* were used for the experiments. Sexing of *C. maculatus* adults was done following the methods of Halstead (1963).

c) Assessment of the effects of solar radiation on C. maculatus

Twenty seeds of previously sterilized cowpea seeds were infested with 5 pairs (5 males and 5 females) of newly emerged adults in Petri dishes and replicated three times. Petri dishes containing 20 seeds and the insects were exposed to solar radiation and later removed appropriately and leave on the bench in the laboratory for 7 days. On the 2nd day, the number of mortality was taken, the adults were allowed to lay eggs for another 3 days after which adults were removed from the treatments. The effects of solar radiation were evaluated by exposing Petri dishes and its content to solar radiation for 1, 2 and 3 hours from 12:00 to 1:00PM, 12:00 to 2:00PM and 12:00 to 3:00PM respectively. Data were taken on the number of eggs laid, number of seeds with eggs and without eggs, number of seeds with and without holes, number of adults that emerged, and fecundity of individual female *C. maculatus*.

d) Experimental design and data analysis

The experiment on the effects of solar heat (1, 2 and 3 hours) was laid out in a Completely Randomized Complete Design replicated three times. Data obtained as count were square root transformed and Analysis of Variance (ANOVA) performed using Statistical Package for Social Sciences (SPSS) version 15. Means were separated using Turkey's HSD test at 95% level of significance.

III. Results

Results in Table 1 showed that solar radiation was effective against *C. maculatus.* Exposure to solar radiation significantly reduced the population of *C. maculatus.* Adults exposed to 3 hours of sun had the highest mortality value (10.50) while those exposed for 1 hour had the least value (5.83). There were no significant differences ($P>0.005$) in the mortality of adults exposed to radiation for 1 and 2 hours but there was a significant

© 2018 Global Journals

difference ($P<0.05$) in the mortality of *C. maculatus* exposed to solar radiation at 3 hours. Exposure to solar radiation significantly reduced the numbers of eggs laid by *C. maculatus* with the least number (2.82) of eggs laid by *C. maculatus* exposed for 3 hours and was significantly different ($P<0.05$) from those exposed to 1 and 2 hours of solar radiation (Table 1).

Highest number of seeds with eggs was obtained on *C. maculatus* exposed at 1 hour which was not significantly different ($P>0.05$) from that exposed at 2 hours. However, at 3 hours of exposure to solar radiation there was a significant difference ($P<0.05$). There were significant differences ($P<0.005$) in the number of seeds without eggs in Table 1. The least numbers of seeds without eggs was recorded were *C. maculatus* was exposed for an hour and was statistically different from those exposed for 2 and 3 hours. Fecundity of individuals *C. maculatus* was reduced by the exposure to solar radiation with the least number of eggs per female obtained when was exposed for 3 hours.

There was no significant difference ($P>0.05$) in the fecundity of *C. maculatus* at 1 and 2 hours of exposure to solar radiation while those exposed to solar radiation for 3 hours was significantly different ($P<0.05$) from those exposed for 1 and 2 hours.

Table 1: Effects of solar radiation on adult mortality, number of eggs laid, seeds with and without eggs

Treatments in Hour (s)	Mortality	No. of Eggs laid	No. of seeds with eggs	No. of seeds without eggs	Fecundity of individual
1	5.83b	9.83a	13.50a	7.50b	1.87a
2	7.17b	7.17a	4.17b	16.83a	1.33a
3	10.50a	2.83b	1.17b	19.83a	0.15b

Means with the same letter in the same column are not significantly different from one another using Turkey's HSD test at $P<0.05$

The number of seeds with holes reduces with the hour of exposure to solar radiation. There were no significant differences ($P>0.05$) in the number of seeds with holes when cowpea seeds were exposed at 1 and 2 hours to solar radiation but significantly ($P<0.05$) least number (1.50) of seeds bearing holes was observed at 3 hours of exposure (Table 2). The numbers of seeds without holes increased with exposure time in Table 2. There was no significant difference in the numbers of seeds without holes of the cowpea exposed at 1 and 2 hours to solar radiation but significant difference ($P<0.05$)was indicated at 3 hours of exposure with highest number (7.17) of seeds without holes.

From table 2, the number of adult's *C. maculatus* that emerged was highest (13.83) at 1 hour of exposure compared with those of 2 and 3 hours. At 3 hours of exposure to solar radiation only an adult emerged and was significantly different ($P<0.05$) from values obtained at 1 and 2 hours of exposure. The weight loss occasioned by the *C. maculatus* infestation showed no significant difference ($P>0.05$) at 1 and 2 hours of exposure. However, the least value (0.15) weight loss obtained on seeds exposed to solar radiation for 3 hours was significantly different from the other times exposure (Table 2).

Table 2: Effects of solar radiation on number of seeds with and without holes, emerged adults and fecundity of individual

Treatment (Hour(s))	No of seed with holes	No of seeds without holes	No of emerged adults	Weight loss (g)
1	5.50a	1.83b	13.83a	2.18a
2	3.83a	5.50a	7.50a	1.18a
3	1.50b	7.17a	1.12b	0.15b

Means with the same letter in the same column are not significantly different from one another using Turkey's HSD test at $P<0.05$

In figures 1 and 2, the trend of the effects of exposure time on the mortality, eggs laid, emerged adults and weight loss occasioned by the beetles was revealed. The mortality of the beetle increased with the increasing hour of exposure while the number of eggs that was laid decreased with the hour of exposure. However, both the number of emerged adults and weight loss decreased substantially with the increasing exposure time (Fig 2).

© 2018 Global Journals

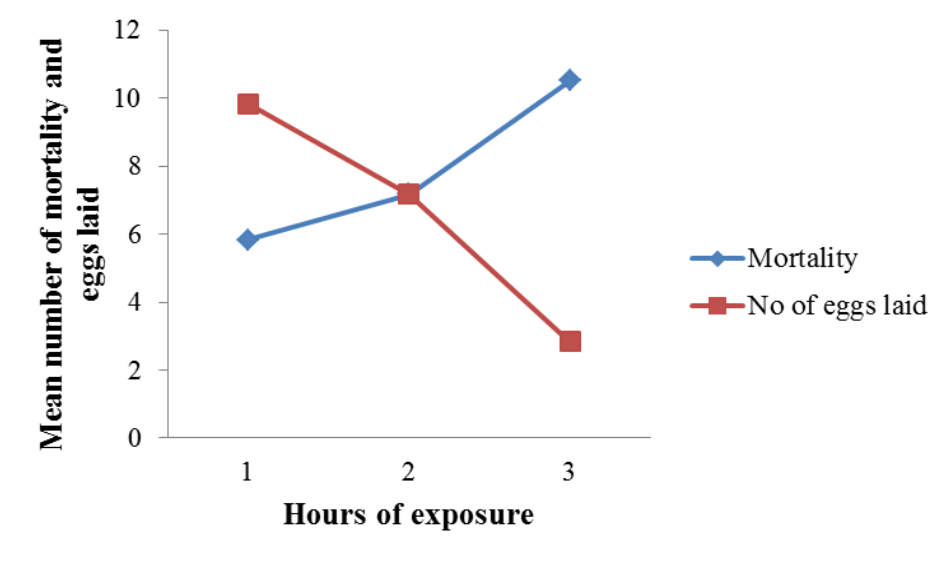


Figure 1: Effects of hour of exposure to solar radiation on the mortality and eggs laid of *C. maculatus*

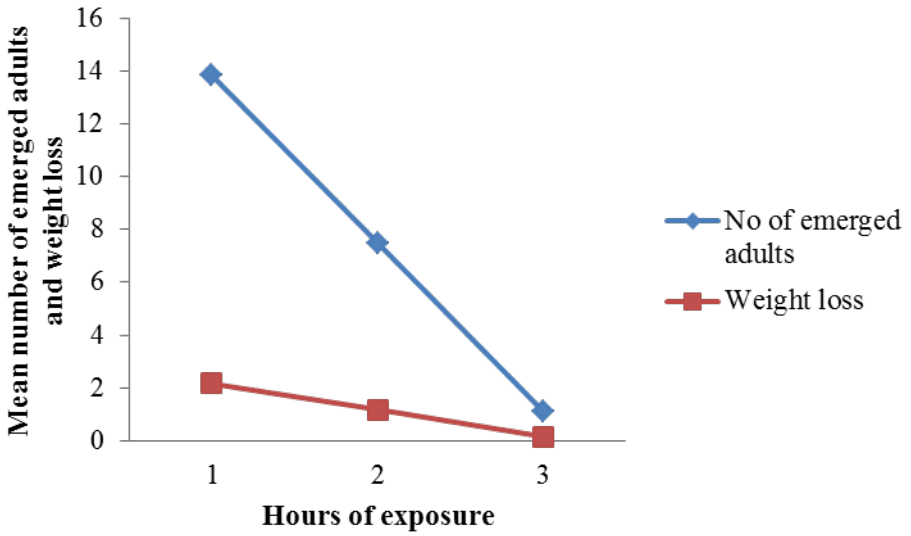


Figure 2: Effects of hour of exposure to solar radiation on the number of emerged adults and weight loss caused by *C. maculatus*

IV. Discussion

The results obtained in this study revealed no significant differences in the weight loss of the cowpea but the mortality of *C. maculatus* was increased by the exposure to solar radiation. These results are consistent with those obtained by Sembene *et al.,* (2006) on groundnut where the authors showed that under extreme temperatures over 33°C, weight loss caused by *Caryedon serratus* was reduced. In another experiment, one hour of exposure to sun radiation in a device used by Murdock *et al.,* (1991) was sufficient to kill all stages of *C. serratus.*

However, the sun exposure significantly reduced the level of infestation of seeds by *C. maculatus* with reduced number of eggs laid by adults exposed for 3 hours to sun radiation which was significantly lower than that deposited by adults with 1 hour and 2 hours of exposure. This low level of infestation of seeds by female *C. maculatus*, sun radiation can be explained by the behavior of these insects that prefer to hide under the seeds during the day time instead of laying (Doumma and Seyni, 2014). Furthermore, it appeared from the analysis of the egg laying, adults exposed to sun radiations, that this technique inhibits the hatching of deposited eggs leading to a higher high rate of abortions and affect larval development. The resulting effects of the radiations lead to an inhibition of the emergence of the offspring. (Doumma *et al.,* 2006).

© 2018 Global Journals

There was a decrease in insect emerging from seeds exposed to sun radiations. This reduction of emergence of larvae could be due to the intensity of the sun radiation that penetrated in the seeds. It could also be related to the difficulty encounter by the newly hatched larvae in penetrating the seeds either because of the heat or because of an increase in the hardness of seeds after the loss of their moisture content (Lale, and Vidal, 2003). This condition should naturally results in a significant reduction of the initial infestation rate of the seeds before storing them. Thus, sun radiations, by negatively influencing the growth parameters of *C. maculatus* appears to be an effective preventive measure of seeds store from cowpea beetles in general and *C. maculatus* in particular.

The results obtained in this study further explained the observations of (Doumma, 2007; Doumma and Seyni, 2014) which showed that exposure of cowpea pods to sun radiations for up to four weeks considerably limits the evolution of populations of beetles and their parasitoids. The study further shows the reduction in the fecundity rate of *C. maculatus* when exposed to sun radiation at different solar range. The effect of this method on the various biological parameters of *C. maculatus* is related to a reduction of water content of the seed (Doumma and Seyni, 2014).

According to Cruz (1988) when the water content of the seeds is very low, the eggs hatching is inhibited, and the larvae fail to develop. This method also promotes the departure of adult beetles that cannot tolerate extreme heat or intense sunlight (in stock, insects are often confined in darker areas).

V. Conclusion

Damage to cowpea seeds by *C. maculatus* during storage is widespread in Africa and constitutes a major constraint to food availability. Preservation of cowpea seeds to reduce losses due to bruchid's infestation is very important. Thus, in order to provide and make available the important dieting protein in cowpea seeds to the people in the tropics who depend on it, the reduction or prevention of *C. maculatus* damage to cowpea seeds meant for consumption and long storage by exposure to solar radiation of cowpeas can be adapted. Thus, solar radiation at 1 hour, 2 hours and 3 hours, were effective in causing mortality of cowpea bruchid and protecting cowpea seeds against *C. maculatus.*

Recommendation

This radiation method could be incorporated into the integrated management strategy of *C. maculatus* on stored cowpea.

References Références Referencias

1. Adebayo, R.A. and Hassan, G.F. (2017). Assessment of pathogens associated with four varieties of cowpea seeds infested with *Callosobruchus maculatus* (F.) [Coleoptera: Chrysomelidae] in the Laboratory. Proceedings of the 3rd annual conference of the Association of Seed Scientists of Nigeria, Abuja, 2nd to 5th July, 2017. Adebisi, M.A., Adetumbi, J.A., Olasoji, J.O. and Fayeun, L.S. (eds), pp158-168.
2. Adebayo, R. A. (2015). Food evaluation and response of *C. maculatus* to oils from seeds of groundnut and bitter kola. Ph.D. Thesis, University of Ilorin, Kwara State. 145 p.
3. Adedire, C.O. (2001). Biology, Ecology and control of insect pests of stored cereal garins. In Ofuya, T.I. and Lale, N.E.S (Eds.). Pest of Nigeria: Biology, Ecology and Control Dave Collins Publications Nigeria, pp. 59-94.
4. Adeduntan, S.A. Ofuya, T.I. (1998). Evaulation of seeds of selected varietes of cowpea, *Vigna unguiculata* (L.) Walp for susceptibilty to *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Applied Tropical Agriculture,* 3: 45-51. Africa'', In: Singh, B.B., Mohan-Raj, D.R., Dashiell, K.E.& Jackai, L.E.N. (Eds.), Advances in cowpea
5. Akinkulore, R.O., Adedire, C.O. and Odeyemi, O.O. (2006). Laboratory evaluation of the toxic properties of forest anchomanes, *Anochomanes difformis* against pulse beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae). *Insect Science*, 13:25-29.
6. Anonymous, 1989. Intern Institute of Tropical Agriculture. *Research Brief,* vol. 9. Ibadan, Nigeria.
7. Begum, S., Mannan, A. and Begun, A., (1991). Effect of sunning on different pulse seeds infested by the pulse beetle *Callosobruchus chinensis* (L.). *Bangladesh J. Zool.* 19:262-5
8. Caswell, G.H. and S. Akibu, 1980. The use of Primiphos- Methyl to control bruchids attacking selected varieties of stored cowpea. *Trop. Grain Legume Bull.,* 17/18:9-11
9. Doumma A, and Seyni (2014). Effects of sun ecposition on theinfestation levels of bruchids population in cowpea (*Vigna unguiculata* (L.) Walp) storage system in Niger. Belgian *Journal of Entomology. Vol. 8.*
10. Doumma, A., Liman, A.I., Toudou, A and Alzouma, I (2006). Comportment de vingt variétés de niébé *(Vigna unguiculata* (L.) Walp.) vis-á-vis de *Bruchidius atrolineatus (*Pic) et *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Cahiers Agricul., 15 (2): 187
11. FAO (Food and Agriculture Organization), (2005). Cowpea production Data Base for Nigeria, 1999-2004. Retrieved from :http://www.faostat.fao.org/.
12. Follett PA, Yang M-H, Lu K-H and Chen T-W 2007. Irradiation for post-harvest control of quarantine insects. *Formosan Entomol.* 27:1-15.
13. Fox, C.W., M.L. Bush, D.A. Roff, and W.G. Wallin. 2004. Evolutionary genetics of lifespan and mortality

© 2018 Global Journals

rates in two populations of seed beetles, *Callosobruchus maculatus.* Heredity 92:170-181.
14. Halstead D.G.H. 1963. External sex differences in stored products Coleoptera. Bulletin Research of Entomological 54: 119-134.
15. IITA. 2000. /crops and farming systems. http://www.iita.org/crop/cowpea.htm. *Indian Journal of Entomology,* 32:303-310
16. Lale, N.E.S and Vidal, S. (2003). Effect of constant temperature and humidity on oviposition and development of *Callosobruchus maculatus* (F.) and *Callosobruchus subinnotatus* (Pic) on Bambara groundnut *Vigna subterranea* (L.) Verdcourt. Journal of Stored Products Research 39(5):459-470.
17. McFarlane, N.R. (1977). *Crop Protection Agents –Their Biological Evaluation*. Academic Press, London.
18. Murdock L.L. and Shade R.E. 1991. Eradication of cowpea weevil (Coleoptera: Bruchidae) in cowpea by solar heating. Am. Entomol., 37(4), 228-231.
19. Nwanze, K.F. (2000). Evidence of ovipositional preferences of *Callosobruchus maculatus* (F.) for varieties. Env. 4:409-412.
20. Nyankori, J. 2002. *Product life cycle model of cowpea based products on Ghana.* Department of Agricultural and applied economics. Clemson University, Clemson, SC. USA. 20pp (also available at www.cherikee.agecon.clemson.edu/wp052402.pdf
21. Ofuya, T. I. (2003). *Beans, insects and man*. Inaugural lecture series 35. The Federal University of Technology, Akure, Nigeria. 45 pp.
22. Ofuya T.I. & Bamigbola K.A., 1991. Damage potentials, growth and development of seeds beetle, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) on some tropical legumes. Tropical Agric (Trinidad) 68, 33-36.
23. Ogunwolu, E.O. and Odunlami, A.T. (1996). Suppression of seed bruchid *Callosobruchus maculatus* (F.) development and damage on cowpea (*Vigna unguiculata* (L.) Walp.) with *Zanthoxylum zanthoxyloides* (Lam.) Weterm. (Rutaceae) root bark powder when compared to neem seed powder and pirimiphos-methyl. Crop protection 15: 603-607. Overseas Development Natural Resources Institute, Chatham, Kent, U.K.
24. Olotuah, O. F., Ofuya, T. I and Aladesanwa, R. D. (2007) Comparison of four botanical powders in the control of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) and Sitophilus (Mots) (Coleoptera: Curculionidae). Proceedings of the Akure – Humboldt Kellong (3rd SAAT annual conference: Medicinal Plants in Agriculture, The Nigeria Experience pp. 56-59.
25. Sanginga N, Dasheli K.E., Diels J, Vanlauwe B., Lyasse O., Carsky R.J., Tarawali S., Asafo-Adjei B., Menkir A., Schulz S., Singh B.B., Chikoye D., Kearings D., Ortiz R. (2003). Sustainable resources management coupled to resilent germplasm to provide new intensive cereal-grain-legume-livestock systems in the dry savannah. Agric. Ecosys Environ. 100:305-314.

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Simulating Wheat Yield under Changing Temperature, Carbon Dioxide and Solar Radiation Levels in Bangladesh

By S. Ishtiaque, R. Sen, M. A. H. S. Jahan, Apurba K. Choudhury, S. Akhter, F. Ahmed, Jatish C. Biswas, M. Manirruzaman, M. Muinnuddin Miah, M. M. Rahman, A. S. M. M. R. Khan, Naveen Kalra & M. B. Hossain

Bangladesh Agricultural Research Institute

Abstract- The wheat crop in the tropical region will be most sufferers because of increased temperature in future. Calibrated and validated DSSAT (CERES-Wheat) model was used to evaluate the impact of increased temperatures (1-3°C), elevated CO_2 (450 and 550 ppm) levels and radiation changes (5% and 10% increase and decrease) on the yield of wheat in Bangladesh. The highest grain yield of 5194 kg ha^{-1} was obtained from BARI Gom-28 followed by BARI Gom-27 (4866 kg ha^{-1}) and BARI Gom-26 (4573 kg ha^{-1}) under existing temperature conditions. Wheat yield at Gazipur increased with elevated atmospheric CO_2 concentration but decreased with the increase in temperature. On an average, 11.95, 18.97 and 22.82 percent yield reductions were observed with 1, 2 and 3-degree rise in temperatures, respectively under ambient CO_2 level at Gazipur. About 2-4% yield compensations are likely if the CO_2 level is increased up to 550 ppm. In Dinajpur area, grain yield of wheat (BARI Gom-28) also reduced by about 6-25% depending on temperature rise.

Keywords: *wheat yield, CERES-wheat model, solar radiation, temperature, co_2 concentration, bangladesh.*

GJSFR-D Classification: *FOR Code: 070106*

Strictly as per the compliance and regulations of:

© 2018. S. Ishtiaque, R. Sen, M. A. H. S. Jahan, Apurba K. Choudhury, S. Akhter, F. Ahmed, Jatish C. Biswas, M. Manirruzaman, M. Muinnuddin Miah, M. M. Rahman, A. S. M. M. R. Khan, Naveen Kalra & M. B. Hossain. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Simulating Wheat Yield under Changing Temperature, Carbon Dioxide and Solar Radiation Levels in Bangladesh

S. Ishtiaque [α], R. Sen [σ], M. A. H. S. Jahan [ρ], Apurba K. Choudhury [ω], S. Akhter [¥], F. Ahmed [§], Jatish C. Biswas [χ], M. Manirruzaman [ν], M. Muinnuddin Miah [Θ], M. M. Rahman [ζ], A. S. M. M. R. Khan [£], Naveen Kalra [€] & M. B. Hossain [₣]

Abstract- The wheat crop in the tropical region will be most sufferers because of increased temperature in future. Calibrated and validated DSSAT (CERES-Wheat) model was used to evaluate the impact of increased temperatures (1-3°C), elevated CO_2 (450 and 550 ppm) levels and radiation changes (5% and 10% increase and decrease) on the yield of wheat in Bangladesh. The highest grain yield of 5194 kg ha^{-1} was obtained from BARI Gom-28 followed by BARI Gom-27 (4866 kg ha^{-1}) and BARI Gom-26 (4573 kg ha^{-1}) under existing temperature conditions. Wheat yield at Gazipur increased with elevated atmospheric CO_2 concentration but decreased with the increase in temperature. On an average, 11.95, 18.97 and 22.82 percent yield reductions were observed with 1, 2 and 3-degree rise in temperatures, respectively under ambient CO_2 level at Gazipur. About 2-4% yield compensations are likely if the CO_2 level is increased up to 550 ppm. In Dinajpur area, grain yield of wheat (BARI Gom-28) also reduced by about 6-25% depending on temperature rise. BARI Gom-28 gave the highest grain yield (5006 kg ha^{-1}) with 10% increase in solar radiation but, grain yield decreased and the yield was 4182 kg ha^{-1} with the reduction of solar radiation by 10%. About 4.43% and 7.70% yield increase was predicted if solar radiation increases by 5 and 10%, respectively compared to no radiation changes; whereas 4.94% and 10.02% yield reductions was simulated with 5 and 10% decrease in solar radiation, respectively. Reduction in solar radiation and rise in temperature would reduce wheat yield in Bangladesh, although increased atmospheric CO_2 levels might reduce the yield reduction rates.

Keywords: wheat yield, CERES-wheat model, solar radiation, temperature, co_2 concentration, bangladesh.

Author α: M.S., Scientific Officer, On Farm Research Division, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mail: sheikh11ishtiaque@gmail.com
Author σ: Ph.D., Senior Scientific Officer, Soil Science Division, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mail: senranjitbd@yahoo.com
Author ρ: Ph.D., Principal Scientific Officer, Planning and Evaluation Wing, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mail: belal.bari@gmail.com
Author ω: Ph.D., Principal Scientific Officer, On Farm Research Division, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mails: bd_apurba@yahoo.com, apurba.chowdhury@gmail.com
Author ¥: Ph.D., Principal Scientific Officer, Soil Science Division, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mail: sohela_akhter@yahoo.com
Author §: Ph.D., Principal Scientific Officer, Plant Physiology Division, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mail: faruquebari@gmail.com
Author χ: Ph.D., Ex. Chief Scientific Officer, Soil Science Division, BRRI, Gazipur 1701, Bangladesh Rice Research Institute, Gazipur, 1701, Bangladesh. e-mail: jatishb@yahoo.com
Author ν: Ph.D., Principal Scientific Officer, Irrigation and Water Management Division, BRRI Gazipur 1701, Bangladesh Rice Research Institute, Gazipur, 1701, Bangladesh. e-mail: mzamaniwm@yahoo.com
Author Θ: Ph.D., Prof, Dept. of Agroforestry, BSMRAU, Salna, Gazipur 1706, BSMRAU, Salna, Gazipur 1706, Bangladesh.
e-mail: mmumiahbsmrau@gmail.com
Author ζ: Ph.D., Prof, Dept. of Soil Science, BSMRAU Salna, Gazipur 1706, BSMRAU, Salna, Gazipur 1706, Bangladesh.
e-mail: mizan@bsmrau.edu.bd
Author £: Ph.D, Chief Scientific Officer, On Farm Research Division, BARI, Gazipur 1701, Bangladesh Agricultural Research Institute, Gazipur, 1701, Bangladesh. e-mail: mahbuburofrd@gmail.com
Author €: Ph.D., Ex-head: Agro-Physics Dept., IARI, New Delhi, Division of Agricultural Physics, IARI, New Delhi, 110012, India.
e-mail: drnkalra@gmail.com
Author ₣: M.S., Scientific Officer, Irrigation and Water Management Division, BRRI Gazipur 1701, Bangladesh Rice Research Institute, Gazipur, 1701, Bangladesh. e-mail: belal.iwm@gmail.com

I. Introduction

Wheat is one of the vital cereals in Bangladesh (BBS, 2014). In general, the productivity of wheat is lower compared to other parts of South Asia, which could be primarily because of short growth duration. Prevailing weather conditions largely dictate crop growth duration and, so does grain yield. Weather elements directly influence the physiological processes of the crop, which affect vegetative and, reproductive stages (Win, 2014). Inter and intra-seasonal variability in temperature, rainfall and, solar radiation may have a significant effect on growth and yield of wheat (Ahmed and Hassan, 2011). The global atmospheric temperature is increasing along with changes in CO2 concentration and depletion in the ozone layer, crop production will be affected significantly (IPCC, 2014).

Wheat yield, in general, depends on varietal character, inputs and agronomic management practices, soil properties and weather conditions. As wheat is a thermo-sensitive crop, and grown in the winter season in Bangladesh, the duration is relatively

© 2018 Global Journals

shorter. So, minimum temperature during January and maximum temperature in February determine the wheat yield (Aggarwal and Kalra, 1994; Kalra et al., 2008). Besides, solar radiation also influences the growth and yield of wheat (Kalra et al., 2006). Wheat yield reduction could be 400 kg ha^{-1} per 1°C increase in temperature (Rai et al., 2004). However, increase in atmospheric CO_2 level and, solar radiation has a positive effect on wheat yield. Increase in atmospheric CO_2 stimulates photosynthesis and inhibits photo-respiration in wheat (Amthor, 2001). The Combined effect of temperature, CO_2 concentration rise and solar radiation change is imperative for growth and yield of crops that can be simulated through models (Aggarwal et al., 2006; Aggarwal et al., 1994; Aggarwal and Kalra, 1994).

Crop model is a practical tool and has recently been accepted worldwide (Droogers and Hunink, 2012). It can put together weather, soils, genotype, and crop management that influence crop yield and economic returns. It can also be used in future climate change scenarios analyses that cannot be evaluated rapidly or economically through field experimentation (Clemente et al., 2005). A particular strength of crop model is its ability to quantify the variability of crop performance due to variability in seasonal weather conditions and to predict the long-term impacts of climate change and land use and land cover change options.

Increase in atmospheric temperature and CO_2 levels is a scientific fact and such situations will affect crop sector in Bangladesh. However, it is costly and time-consuming to create futuristic climate scenarios for studying climate change impacts on wheat production in Asian countries. DSSAT is a dynamic crop simulation model, which can competently be used to predict the performance of wheat against the changing climate. So, in the present study, DSSAT Version 4.6 (CERES-Wheat) was used to evaluate the interactions of temperature, CO_2 levels and radiation changes on wheat yield in Bangladesh.

II. Materials and Methods

a) Soil and climate of the experimental site

The simulation study was carried out at Bangladesh Agricultural Research Institute (BARI), at Gazipur (23.59°N and 90.24°E, and 8 m above mean sea level) and Dinajpur (25.63°N and 88.63°E, and 39 m above sea level). Soil characteristics of Gazipur and Dinajpur are shown in Table 1a & 1b and Table 2a & 2b, respectively. Gazipur soil belongs to Grey Terrace Soil, with silty clay loam texture and Dinajpur soil belongs to Grey Flood Plain Soil, having sandy loam texture. These values were used to develop particular profiles that to be added to Soil. Sol file use for running of DSSAT.

Climatic data were collected from the weather station of Gazipur and Dinajpur under the Department of Metrology, Government of Bangladesh. Daily values of various climatic elements (historical weather datasets) were used to prepare annual weather files, by running Weatherman- a module in DSSAT, required for running of the model. Monthly averaged maximum and minimum temperatures, total rainfall and sunshine hours of the two study sites Gazipur and Dinajpur were presented in Table 3a and 3b, respectively.

b) Model description

DSSAT v.4.6 model (CERES-Wheat Crop Simulation Model) was used for the present study. The model runs with six datasets viz. Soil file, Weather file, Genetic coefficients file, Experimental file (X file), Annual file (A) and Time-course file (T file) (Hoogenboom, 2000; Hoogenboom et al., 2003). Soil data includes soil characteristics such as site latitude and longitude, soil type and soil series, pH, bulk density, soil texture and soil nutrient status like N and C content. Weather file includes daily temperature (both maximum and minimum), humidity, solar radiation, rainfall, etc. DSSAT model requires some of crop management data (crop, variety, planting date, row and plant spacing, fertilizer levels, tillage practices and organic amendments) in the experimental file (X file) to simulate crop productivity. Data on physiological stages of crop growth such as anthesis date, days to maturity and grain yield were also included in Annual (A) file. The time course values of biomass, yield and leaf areas are used to prepare T file. These files were for calibration and validation and subsequent use in climate change impact analysis on wheat.

c) Impact evaluation of climate change on wheat

Four separate studies were simulated to predict climate change impact on wheat yield. Effect of temperature and CO_2 concentration on BARI Gom-25, BARI Gom-26, BARI Gom-27 and BARI Gom-28 at Gazipur location was studied. Temperature rises considered were 0, 1, 2 and 3°C and CO_2 levels were 380 and, 450 ppm Effects of increased temperatures (0, 1, 2 and 3°C) and CO_2 concentration (380, 450 and 550 ppm) on BARI Gom-28 were studied for Dinajpur location. Effect of solar radiation change on BARI Gom-26 yield was simulated by considering both reduction and increase in solar radiation (5 and 10%) and compared with no changes. Interaction effect of rising temperature and solar radiation on grain yield of BARI Gom-26 was studied considering 0, 1 and 2°C rise in temperature and 0 and 10% reduction in solar radiation.

d) Genetic coefficients

Genetic coefficients of BARI Gom-25, BARI Gom-26, BARI Gom-27 and BARI Gom-28 were computed by using GLUE module of DSSAT and are shown in Table 4. Here, P1V means optimum vernalizing temperature, required for vernalization expressed in days; PID indicates photoperiod response (% reduction

© 2018 Global Journals

in rate/10 h drop in pp). P5 means grain filling (excluding lag) duration (°C-d). G1, G2 and, G3 specify kernel number per unit canopy weight at anthesis (#/g), standard kernel size under optimum conditions (mg) and standard, non-stressed mature tiller wt (incl grain) (g dwt); respectively. PHINT indicates the interval between successive leaf tip appearances expressed in °C-d.

e) Model application

DSSAT Version 4.6 model (CERES-Wheat) was run for historic 30 years from 1980 to 2010 AD. Predicted wheat yields were generated using Seasonal Module run of DSSAT. Scenarios (on by historic runs) were collated to assess the sensitivity of the crop performance to changes in temperature, CO_2 concentration and, solar radiation.

III. Results and Discussions

a) Calibration and validation of DSSAT

Figure 1 shows the performance of the CERES-Wheat model based on observed and simulated yields of BARI Gom-25, 26, 27 and 28. The simulated yields were very close to observed yields and followed a 1:1 line, indicating that the model was performing well for simulating the yield of wheat grown in Bangladesh environment. The trend line showed satisfactory predictability as seen through high R^2 value.

b) Effect of temperatures and CO_2 concentration on wheat yield at Gazipur

The effects of elevated CO_2 concentration and temperature rise on grain yield of wheat are shown in Figure 2. Grain yield of all wheat varieties increased with the increase of CO_2 levels but decreased with higher temperatures. BARI Gom-28 gave the highest grain yield of 5194 kg ha^{-1} followed by BARI Gom-27 (4866 kg ha^{-1}) and BARI Gom-26 (4573 kg ha^{-1}) under no temperature increased conditions. The decrease in wheat yield because of temperature rise by 1, 2 and 3°C at 380 ppm CO_2 level was 11.95, 18.97 and 22.82 percent, respectively. In the same location with 550 ppm CO_2 concentration, simulated wheat yield reductions were 6.56%, -0.19% and -3.89% because of rising in temperature by 1, 2 and 3°C, respectively compared to ambient climatic conditions (Table 5). Similar findings were reported by Lobell et al. (2012) for northern India. Compensating yield factor for cereals under increased temperature conditions is often referred by the CO_2 fertilization (Boulidam, 2012).

Simulated average grain yields of wheat as influenced by increased temperature rise at varying CO_2 concentrations are prsented in Table 5. On average over varieties, about 10.58%, 16.92% and, 20.38% yield reductions were observed because of 1, 2 and 3°C temperature rise, respectively. Temperature plays a massive role for growth and yield of wheat (Aggarwal et al., 2006) and optimum temperature limit for physiological activities of wheat is probably exceeded in the tropical region (Hogan, 1991). Pre-anthesis and post-anthesis high-temperature stress reduced the photosynthetic efficiency of the crop (Wang et al., 2011) and thus reduces yields. You et al. (2009) also observed a significant reduction in wheat yield because of temperature rise. They reported 3-10% reduction in wheat yields due to 1.8°C rising in temperature.

Table 5 shows the fertigation effects of increased CO_2 levels on wheat yields. Up take of more CO_2 from the air by the plants are positivily influenced on growth processes (Ackerman and Stanton, 2013) and thus adverse effects of increased temperatures are compensated to a noticeable extent (Basak, 2010).

c) Effect of temperatures and CO_2 concentration on wheat yield at Dinajpur

Grain yield of BARI Gom-28 decreased with increase in temperature (Fig. 3). The highest grain yield was 5944 kg ha^{-1} at 380 ppm CO_2 under ambient temperature conditions. Irrespective of CO_2 levels, yield reductions were 6.74%, 17.46% and, 24.50%, respectively under 1, 2 and 3°C temperature rise. Temperature rise primarily reduces crop growth duration, especially grain filling duration and thus reduction in grain yield. Similar results were reported by Kalra et al. (2008) for wheat in New Delhi environment. Ackerman and Stanton (2013) also found similar trends of yield reduction because of elevated temperature. On the other hand, increased atmospheric CO_2 levels improved grain yield of wheat. The highest grain yield of BARI Gom-28 was 5327 kg ha^{-1} at550 ppm CO_2 concentration, which was followed by 450 ppm CO_2 (4837 kg ha^{-1}). The lowest grain yield was recorded 4499 kg ha^{-1} with existing CO_2 concentration of 380 ppm. Net availability of photosynthate is the driven force of plant growth and development. Photosynthesis is a process that absorbs CO_2 from the air and converts it into organic compounds such as sugars. If the limiting factor in this process is the amount of CO_2 available to the plant, then an increase in the atmospheric concentration of CO_2 could act as a fertilizer, providing additional nutrients and allowing faster growth. Growth could be limited by the availability of CO_2 in case of wheat as it is belonging to C_3 plant and it is responsive to CO_2 concentration resulting in increased growth and yield (Ainsworth et al., 2008; Ainsworth and McGrath, 2010).

Experimental data from greenhouse and laboratory studies also indicated that the photosynthesis, growth and water use efficiency of tropical plants increased at higher CO_2 levels (Hogan et al., 1991).

d) Effect of solar radiation change on the yield of wheat

Five levels of solar radiation changes like no change, 5% reduction, 10% reduction, 5% increase and

© 2018 Global Journals

10% increase were investigated with BARI Gom-28 (Figure 4). Increased solar radiation showed a positive impact on grain yield of wheat. The highest grain yield (5006 kg ha^{-1}) of BARI Gom-28 was simulated when solar radiation was increased by 10% followed by 5% increase in solar radiation (grain yield was 4854 kg ha^{-1}). Grain yield decreased with the reduction in solar radiation. Reduction in solar radiation by 5% and 10% resulted in 4.94% and 10.02% decrease in grain yield, respectively. The yield increased 4.43% and 7.70% was predicted by the no radiation change. These findings corroborate the results of Ahemd et al. (2011), who reported yield response to changes in solar radiation intercepted by the canopy. Similar results were also reported by Kalra et al. (2006) while evaluating the effect of aerosols on the yield of wheat, rice and, sugarcane.

e) *Effect of solar radiation reduction and temperature rise on the yield of wheat*

The Combined effect of solar radiation reduction and temperature rise on grain yield of BARI Gom-26 is shown in Figure 5. The reduction in solar radiation and increase in temperature reduced wheat yield. The highest grain yield (4648 kg ha^{-1}) of BARI Gom-26 was predicted under no radiation change and, no temperature rise. Grain yield of wheat reduced by 11.42% because of the 1°C rise in temperature and it was 21.40% for 2°C temperature. Similarly, 10% reduction in solar radiation caused 9.87% yield penalty compared to ambient radiation condition. In case of 2°C temperature rise and 10% reduction in radiation, grain yield was only 3291 kg ha^{-1}, which was 29.20% lower than ambient conditions. Similar results have been reported by Ahmed et al. (2011) and Li et al. (2010). Because of enhanced industrial and other anthropogenic activities, the aerosols concentration is increasing in the atmosphere resulting in reduced solar radiation (direct plus diffused) reaching the earth's surface. Developing the climate change scenarios is the changes in temperature and humidity are also associated with the presence of aerosol, its needs to be consider because cooling phenomenon may take place.

IV. Conclusion

Climate change and climatic variability are concerns for Bangladesh, where the frequency of occurrence of extreme climatic/episodic events have increased over the last couple of decades. There is a need to understand the interaction of changes in various climatic elements for growth and yield of wheat. DSSAT Version 4.6 was used for evaluating the interaction amongst temperature rise, solar radiation changes and increase in CO_2 levels. Four varieties of wheat, commonly grown in this region, were undertaken. The model was calibrated and validated for two growing environments of Bangladesh viz. Gazipur and Dinajpur. The model was subsequently run with historical weather (past 30 years) data on temperature, radiation and, CO_2 concentration. In general, wheat yield decreased with the increase in temperature, primarily because of reduced crop growth duration. Elevated CO_2 could nullify the effect of increased temperature to some extent. The decrease in solar radiation, which is expected due to enhanced industrial and other anthropogenic activities, likely to decrease wheat yield further. The results from the present investigations indicated significant interaction amongst these prime climatic elements towards the realization of the wheat yield, and also demonstrating the potential of crop simulation models, DSSAT, in assessing the impact of climate change and its variability on growth and yield of crops and cropping systems.

Acknowledgements

The authors gratefully acknowledge the funding from "Krishi Gobeshona Foundation (KGF)" of Ministry of Agriculture, The Peoples Republic of Bangladesh through "Modeling climate change impact on agriculture and developing mitigation and adaptation strategies for sustaining agricultural production in Bangladesh" project (CRP-II).

References Références Referencias

1. Ackerman, F., Stanton, E.A. (2013). Climate Economics: The State of the Art. Routledge, London.
2. Aggarwal, P.K., Kalra, N. (1994). Analysing the limitations set by climatic factors, genotype, water and nitrogen availability on productivity of wheat II. Climatically potential yields and optimal management strategies. Field Crops Res. 38 (2), 93 - 103.
3. Aggarwal, P.K., Kalra, N., Singh, A.K., Sinha, S.K. (1994). Analysing the limitations set by climatic factors, genotype, water and nitrogen availability on productivity of wheat I. The model description, parameterization and validation. Field Crops Res. 38 (2), 73 - 91.
4. Aggarwal, P.K., Kalra, N., Chander, S., Pathak, H. (2006). Infocrop: A dynamic simulation model for the assessment of crop yields, losses due to pests and environmental impact of agro-ecosystems in tropical environments. II. Model description. Agril. Systems, 89 (1), 1-25.
5. Ahmed, M., Hassan, F.U. (2011). Cumulative effect of temperature and solar radiation on wheat yield. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 39 (2), 146-152.
6. Ahmed, M., Hassan, F.U., Aslam, M.A., Akram, M.N., Akmal, M. (2011). Regression model for the study of sole and cumulative effect of temperature

© 2018 Global Journals

and solar radiation on wheat yield. African J. Biotech, 10 (45), 9114-9121.
7. Ainsworth, E.A., McGrath, J.M. (2010). Direct Effects of Rising Atmospheric Carbon Dioxide and Ozone on Crop Yields. Climate Change and Food Security Advances in Global Change Research, 37 (2), 109–130.
8. Ainsworth, E.A., Leakey, A.D.B., Ort, D.R., Long, S.P. (2008). FACE-ing the facts: Inconsistencies and interdependence among field, chamber and modeling studies of elevated CO_2 impacts on crop yield and food supply. New Phytologist, 179 (1), 5–9. doi: 10.1111/j.1469- 8137.2008.02500.x.
9. Amthor, J.S. (2001). Effects of atmospheric CO_2 concentration on wheat yield: review of results from experiments using various approaches to control CO_2 concentration. Field Crops Res., 73 (1), 1-34.
10. Basak, K.J. (2010). Climate change impacts on rice production in Bangladesh: Results from a model. Unnayan Onneshan-The Innovators, Center for Research and Action on Development, Dhaka, Bangladesh.
11. Bangladesh Bureau of Statistics (BBS), (2014). Year book of agricultural statistics of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.
12. Boulidam, S. (2012). Simulation of climate change impact on low land paddy rice production, Potentialin Savannakhet Province, Laos. (Doctoral dissertation, Institute of Meteorology (BOKU-Met), University of Natural Resources and Life Sciences, Vienna Austria, 2012) Austria: University of Natural Resources and Life Sciences.
13. Clemente, R.S., Asadi, M.E., Dixit, P.N. (2005). Assessment and comparison of three crop growth models under tropical climate conditions. J.of Food, Agril. & Environ., 3 (2), 254–261.
14. Droogers, P., Hunink. J. (2012). Assessment of impact of climate change on wheat in Armenia, Azerbaijan and Georgia. Regional analytical and advisory activities program on developing adaptation and mitigation strategies in the Agricultural Sector for Armenia, Azerbaijan and Georgia. Future Water.
15. Hogan, K.P., Smith, A.P., Ziska, L.H. (1991). Potential effects of elevated CO_2 and changes in temperature on tropical plants. Plant, Cell and Environment, 14: 763–778.
16. Hoogenboom, G. (2000). Contribution of agrometeorology to the simulation of crop production and its applications. Agril. and Forest Meteorology, 103: 137–157.
17. Hoogenboom, G., Jones, J.W., Porter, C.H., Wilkens, P.W., Boote, K.J., Batchelor, et al. (2003). DSSAT version 4 vol. 1. University of Hawaii, Honolulu, HI.
18. Intergovernmental Panel for Climate Change (IPPC). (2014). Climate change 2014 synthesis report and its summery for policymakers. 5th Assessment Report.
19. Kalra. N., Chakraborty, D., Sahoo, R.N., Sehgal, V.K., Singh, M. (2006). For assessing yields under extreme climatic events using crop simulation models: Aerosol layer effects on growth and yield of wheat, rice and sugarcane. In: Kuligowski R.J., Parihar, J.S. (ed) Agriculture and Hydrology Applications of Remote Sensing, Proc. of SPIE, Vol. 6411-6458.
20. Kalra, N., Chakraborty, D., Sharma, A., Rai, H.K., Jolly, M., et al. (2008). Effect of increasing temperature on yield of some winter crops in north-west India. Current Science, 94: 82-88.
21. Li, S., Wheelrb, T., Challinorc, A., Lind, E., Jud, H., Xud. Y. (2010). The observed relationships between wheat and climate in China. Agric Forest Meteor, 150: 1412-1419.
22. Lobell, D.B., Sibley, A., Ivan, Ortiz-Monasterio, J. (2012). Extreme heat effects on wheat senescence in India. Nature Climate Change, 2: 186–189. doi: 10.1038/nclimate1356.
23. Rai, H.K., Sharma, A., Soni, U.A., Khan, S.A., Kumari, K., Chander, S., Kalra, N. (2004). Simulating the impact of climate change on growth and yield of wheat. J. of Agrometeorology, 6: 1-8.
24. Wang, X., Cai, J., Jiang, D., Liu, F., Dai, T., Cao, V. (2011). Pre-anthesis high-temperature acclimation alleviates damage to the flag leaf caused by post-anthesis heat stress in wheat. J. Plant Physiol, 168: 585-593.
25. Whisler, F.D., Acock, B., Baker, D.N., Fye, R.E., Hodges, H.F., Lambert, J.R., et al. (1986). Crop simulation models in agronomic systems. In: Brady NC (ed) Advances in Agronomy, Academic Press, 40: 141–208.
26. Win, C.C. (2014). Evaluation of climate change impacts and adaptation measures for rice production in the central plan of Thailand using CERES-Rice Model. MS thesis, Agricultural Systems and Engineering, Asian Institute of Technology.
27. You, L., Rosegrant, M.W., Wood, S., Sun, D. (2009). Impact of growing season temperature on wheat productivity in china. Agric Meteor, 149: 1009-1014.

© 2018 Global Journals

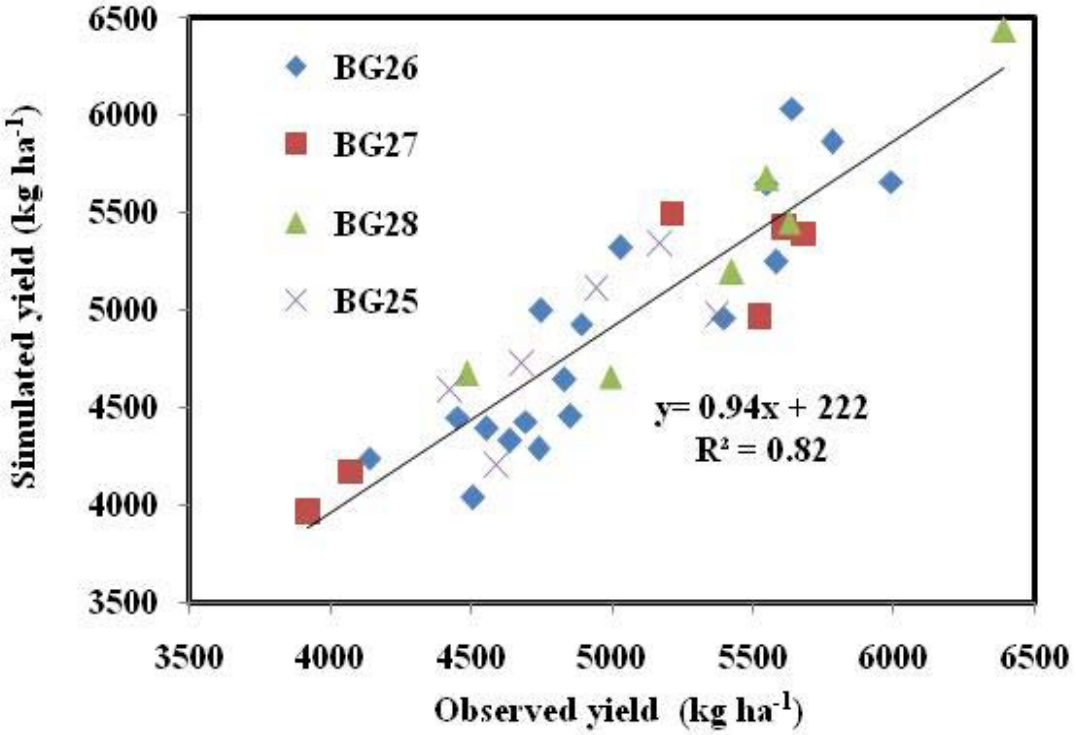


Fig. 1: Performance of CERES-Wheat model based on observed verses simulated yield of BARI Gom-25, 26, 27 and 28

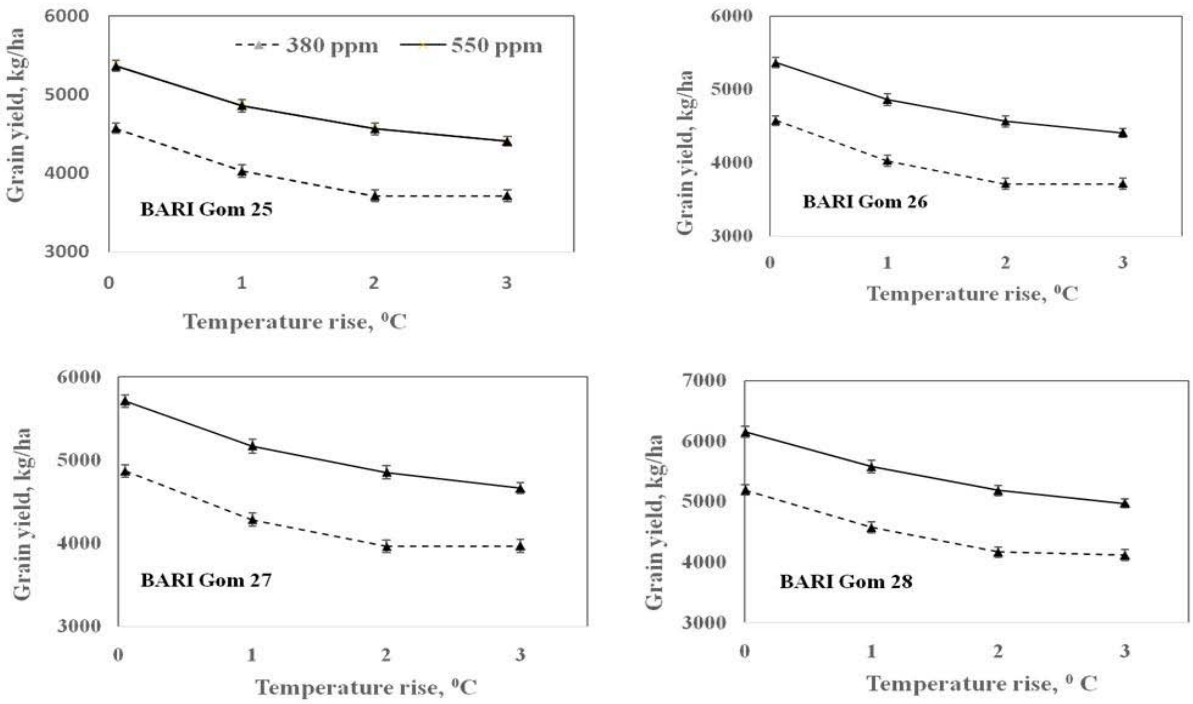


Fig. 2: Effect of increased temperature and CO_2 concentration on grain yield of wheat varieties at Gazipur, Bangladesh

© 2018 Global Journals

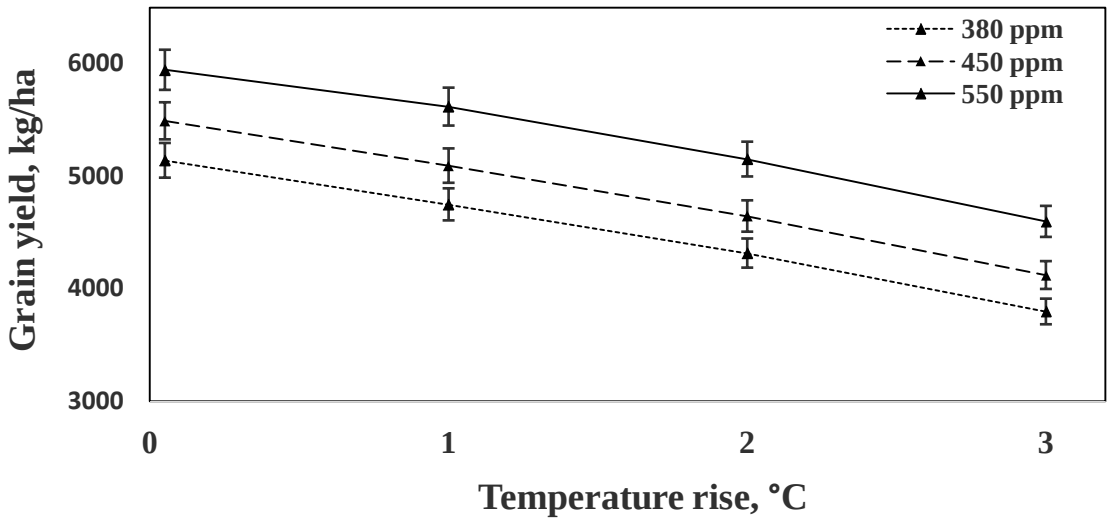


Fig. 3: Effect of increased temperatures and CO_2 concentrations on grain yield of BARI Gom-28 at Dinajpur (30 years run)

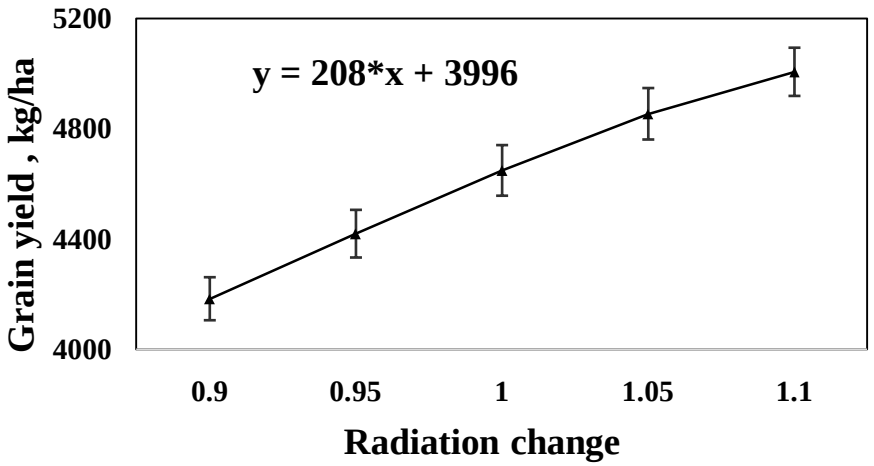


Fig. 4: Effect of solar radiation changes on grain yield of BARI Gom-26 (30 years run) at Gazipur

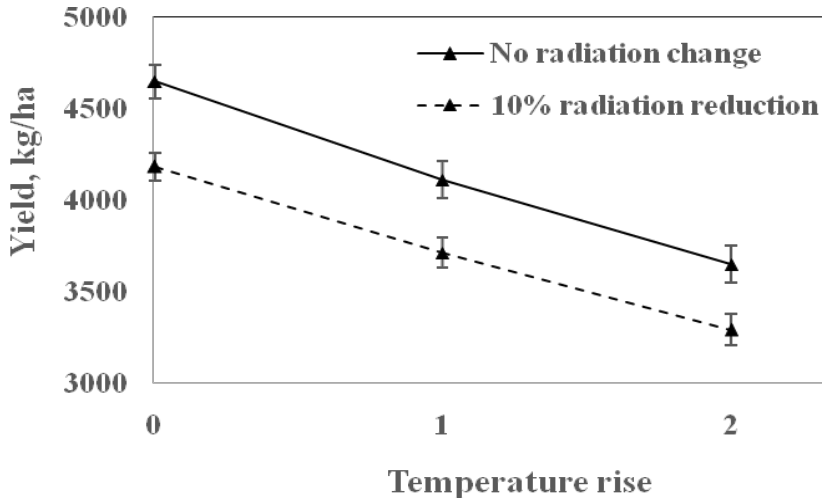


Fig. 5: Eeffect of solar radiation reduction and temperature rise on grain yield of wheat BARI Gom-26 (30 years run) at Gazipur

© 2018 Global Journals

Table 1a: Physical properties of experimental soil (Gazipur location)

Soil layer (cm)	Sand (%)	Silt (%)	Clay (%)	Bulk density (Mg m^{-3})
0-15	30.84	46.42	22.74	1.52
15-30	20.84	47.35	31.81	1.53
30-60	20.48	40.24	39.28	1.56
60-90	23.48	43.71	32.81	1.57
90-120	19.84	42.35	37.81	1.61
120-150	18.84	45.21	35.95	1.63
150-180	19.36	46.28	34.36	1.66

Table 1b: Chemical properties of experimental soil (Gazipur location)

Soil-layer (cm)	pH	Organic carbon (%)	Total N (%)	NO_3^- N (mg kg^{-1})	NH_4^+ N (mg kg^{-1})	Available phosphorous (mg kg^{-1})	Available potassium (meq/100g)
0-15	6.1	1.04	0.11	11.4	1.8	9.06	0.29
15-30	6.2	0.93	0.09	9.8	2.0	8.78	0.27
30-60	6.2	0.77	0.08	7.6	2.2	7.11	0.24
60-90	6.3	0.52	0.06	6.4	2.4	5.63	0.22
90-120	6.4	0.46	0.05	5.3	2.6	5.09	0.18
120-150	6.5	0.41	0.04	4.9	2.8	3.89	0.15
150-180	6.7	0.36	0.03	4.1	2.9	3.21	0.14

Table 2a: Physical properties of experimental soil (Dinajpur location)

Soil layer (cm)	Sand (%)	Silt (%)	Clay (%)	Bulk density (Mg m^{-3})
0-15	61.0	22.7	16.3	1.49
15-30	66.3	11.7	27.3	1.57
30-60	58.3	11.0	30.7	1.59
60-90	55.9	9.4	34.7	1.61
90-120	67.3	14.4	18.3	1.62
120-150	74.3	6.4	19.3	1.67
150-180	74.3	6.3	19.4	1.69

Table 2b: Chemical properties of experimental soil (Dinajpur location)

Oil layer (cm)	pH	Organic carbon (%)	Total N (%)	NO_3^-N (ppm)	NH_4^+N (ppm)	Available phosphorous (ppm)	Available potassium (meq $100g^{-1}$)
0-15	6.1	0.49	0.05	9.8	2.0	6.27	0.26
15-30	6.2	0.28	0.03	7.3	2.1	6.03	0.24
30-60	6.2	0.19	0.02	5.1	2.2	5.18	0.22
60-90	6.3	0.14	0.01	4.7	2.5	4.83	0.19
90-120	6.4	0.13	0.01	4.3	2.7	3.98	0.16
120-150	6.5	0.12	0.01	3.5	3.2	3.19	0.15
150-180	6.7	0.10	0.01	3.0	3.4	2.88	0.13

Table 3a: Weather normals of Gazjpur during growing season of wheat (30 years average)

Month	Average temperature (ºC)		Total rainfall (mm)	Average sunshine hour
	Maximum	Minimum		
November	30.1	16.1	26.1	7.29
December	26.0	12.6	8.2	6.62
January	24.8	12.6	6.5	6.83
February	28.5	14.7	18.9	7.62
March	32.5	18.9	44.8	8.05
April	33.3	21.2	135.1	7.85

© 2018 Global Journals

Table 3b: Weather normals of Dinajpur during growing season of wheat (30 years average)

Month	Average temperature (°C)		Total rainfall (mm)	Average sunshine hour
	Maximum	Minimum		
November	29.0	16.6	15.3	7.22
December	25.1	12.2	6.9	6.49
January	22.9	10.4	5.9	5.94
February	26.5	13.0	12.7	7.51
March	30.9	17.4	11.4	7.89
April	32.9	21.1	65.7	7.41

Table 4: Genetic coefficients of tested wheat varieties

Variety	P1V	P1D	P5	G1	G2	G3	PHINT
BARI Gom-25	0	92	725	23	46	3.6	70
BARI Gom-26	0	92	730	23	46	3.8	70
BARI Gom-27	0	93	740	24	46	3.9	70
BARI Gom-28	0	96	750	25	47	3.9	70

Table 5: Average (four varieties and historic years) grain yields of wheat as influenced by temperature rise at varying CO_2 levels (figures in parenthesis indicate percent change in yields over ambient condition)

CO_2 concentration	Temperature rise (°C)			
	0	1	2	3
380 ppm	4802	4228 (-11.95)	3891 (-18.97)	3706 (-22.82)
550 ppm	5649 (17.64)	5117 (6.56)	4793 (-0.19)	4615 (-3.89)

© 2018 Global Journals

This page is intentionally left blank

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Effect of Moringa Leaves, Poultry Manure and NPK Fertilizers on Growth and Yield of Maize (*Zea Mays* L) in Ilorin, Southern Guinea Savannah of Nigeria

By Yusuf Taibat Moji, Olowoake Adebayo Abayomi & Subair Stephen Kayode
Kwara State University

Abstract- A field experiment was conducted in 2016 and 2017 planting seasons at the Teaching and Research Farm of Kwara State University, Malete, Nigeria to assess the growth and yield response of maize plant to organic and inorganic fertilizer. The study comprised of 6 treatments viz; Control, 100 % NPK 15-15-15, 100 % Moringa leaves (MO), 100 % Poultry manure (PM), 50% Moringa leaves (MO) + 50% NPK and 50% Moringa leaves (MO) + 50% Poultry manure (PM). All the treatments except the control were applied at the rate of 60 kg N/ha. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. Results showed that application of Moringa leaves with NPK at 4, 8 and 12 WAP significantly ($p < 0.05$) increased the growth parameters and grain yield of maize when compared to application of NPK, poultry manure and moringa leaves alone including the control treatment.

Keywords: *growth, maize, moringa leaf, NPK, poultry manure, yield.*

GJSFR-D Classification: *FOR Code: 070199*

Strictly as per the compliance and regulations of:

© 2018. Yusuf Taibat Moji, Olowoake Adebayo Abayomi & Subair Stephen Kayode. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Effect of Moringa Leaves, Poultry Manure and NPK Fertilizers on Growth and Yield of Maize (*Zea Mays* L) in Ilorin, Southern Guinea Savannah of Nigeria

Yusuf Taibat Moji [α], Olowoake Adebayo Abayomi [σ] & Subair Stephen Kayode [ρ]

Abstract- A field experiment was conducted in 2016 and 2017 planting seasons at the Teaching and Research Farm of Kwara State University, Malete, Nigeria to assess the growth and yield response of maize plant to organic and inorganic fertilizer. The study comprised of 6 treatments viz; Control, 100 % NPK 15-15-15, 100 % Moringa leaves (MO), 100 % Poultry manure (PM), 50% Moringa leaves (MO) + 50% NPK and 50% Moringa leaves (MO) + 50% Poultry manure (PM). All the treatments except the control were applied at the rate of 60 kg N/ha. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. Results showed that application of Moringa leaves with NPK at 4, 8 and 12 WAP significantly ($p < 0.05$) increased the growth parameters and grain yield of maize when compared to application of NPK, poultry manure and moringa leaves alone including the control treatment. The highest grain yield (4.5t /ha) was obtained from MO+NPK while the grain yield (3.6 t/ha) were obtained with NPK during 2016 cropping season. The Moringa leaf with NPK had a significant ($p < 0.05$) influence on grain yields of maize during second cropping than NPK alone in 2017. The treatment MO+NPK and NPK alone produced maize grain yield by 4.4 t/ha and3.9 t/ha respectively. Therefore, the use of MO+NPK at 60 kg N/ha was judged more economic than NPK, PM and PM +MO in the studied area.

Keywords: growth, maize, moringa leaf, NPK, poultry manure, yield.

I. Introduction

Maize (*Zea mays* L.) is an annual cereal crop commonly cultivated in most parts of Nigeria. It is a major source of food and livelihood for millions of people in many countries of the world (Ogunsumi *et al.,* 2005). Maize grains are useful raw material in industries for the production of medicines and different food recipes (Otitoju *et al*., 2016). Maize has a multipurpose advantage as every part of it such as the leaves, stalks, tassels and cobs are useful (IITA, 2011). In Nigeria, the increasing rate of demand for maize for different purposes had not been met with the supply from local production (Daramola and Taiwo, 2008). One of the problems of crop production in the tropics is that tropical soils have low fertility status (Agbede, 2010). The soils are highly weathered and leached, low in organic matter and available nutrients, thus leading to low productivity within few years of cultivation (Soremi *et al*., 2017). Applying inorganic fertilizer is one of the widely accepted ways of increasing soil nutrients both in the temperate and tropical zones of the world. However, long term studies have shown that there is a limit to which inorganic fertilizer can sustain the productivity of intensely cultivated soil. This is because of problem of decrease in yield with time, enhancement of soil acidity, leaching losses, and degradation of soil physical and organic matter status(Ojeniyi, 2000).

Research has shown that organic based fertilizers are less leached into ground water than the chemical fertilizer (Sridhar and Adeoye, 2003). As a result of this fact, the use of organic based fertilizer has found favour in boosting crop production in Nigeria, because it is cheap and less likely to pollute the ground water as much as chemical fertilizer. It improves soil fertility status as well as increasing the income of farmers via increase in yield. Thus, there is an increase in studies on organic wastes as alternative fertilizers. Organic wastes provide a continuous decomposing substrate and consequent gradual input of soil organic matter, thereby increasing soil nutrients and improving the soil physical properties.

Animal manure is known to be effective in maintenance of adequate supply of organic matter in soil, with improvement in soil physical and chemical condition and enhanced crop performance (Ikpe and Powel, 2002).Poultry, cattle, sheep and pig manure has been found to improve soil fertility and crop yield. Adeniyan and Ojeniyi, (2005); Ojeniyi and Adegboyega, (2003) reported that addition of poultry and cattle manure to soil lead to increase in soil PH, Organic Carbon, Nitrogen, Phosphorus, Calcium, Potassium, Magnesium, Sodium and CEC. Research on moringa application as fertilizer has been reported to increase the growth, yield and quality of crops. Several re-

Author α ρ: Department of Agricultural Economics and Extension Services, Kwara State University, Malete, Nigeria.
e-mails: tmyusuf01@gmail.com, ssksubair@gmail.com
Author σ: Department of Crop Production, Kwara State University, Malete, Ilorin. Kwara State, Nigeria. e-mails: aolowoake@yahoo.com, adebayo.olowoake@kwasu.edu.ng

© 2018 Global Journals

searches have indicated that *M. oleifera* is a highly valued plant with multipurpose effects (Fuglie, 2000; Yang *et al*., 2006; Anwar *et al*., 2007; Adebayo *et al*., 2011)]. Increase in grain yield of maize has been reported by Mvumi *et al*. (2013). *Moringa oleifera* have been investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Phiri, 2010).

Complementary use of organic and inorganic fertilizers has been proved to be a sound soil fertility management strategy (Law-Ogbomo *et al*., 2011). Organic fertilizer fortified with inorganic materials may be formulated to replenish the soil and improve plant fertilization. It releases nutrients in soil in the form that plants can easily absorb and it can activate soil micro-organisms and increase microbes, which will help the decomposition processes of organic matter. This will promote higher plant growth, healthier crops and better fruit yield. It reduces the needs of chemical fertilizer, which will lead to lower production cost and indirectly increases income (Olowoake, 2014).

There is now a growing demand for sound and ecologically compatible and environment friendly techniques in agriculture, capable of providing enough food for the increasing human population; retaining soil quality and improving the quality and quantity of agricultural produce (Russo, 2012).

However, there is scanty information on the application of poultry manure, moringa, and its complimentary use with inorganic fertilizer that would give the best result in terms of growth performance and yield of maize. This study therefore aims at investigating the effect of different combination of organic and inorganic fertilizers on the growth and yield of maize and to compare the economic use of poultry manure, Moringa leaves, its combination with mineral fertilizer and NPK fertilizer.

II. Materials and Methods

a) Study location

The study was conducted at the experimental plot of Kwara State University, Malete (08^0 42 ′48.5″N and $04^0$26′17.9″E), Ilorin, Nigeria, southern guinea savanna zone of Nigeria in 2016 and 2017 respectively. The region has temperature that varies between 33∘C and 34∘C, annual rainfall in the region is about 1200mm and during the period, with a dry spell from December to March. The Kwara State University land area forms part of the South-western region of Nigerian basement complex, a region of basement recurrence and plutonism during the Pan-African orogeny (Olowoake, 2017).

b) Soil analysis

Soil samples from the study area were analyzed prior to experimentation after collection with the aid of auger from each block. The samples were bulked, air-dried and crushed to pass through a 2mm sieve. Soil analyses were carried out using procedure described by (Okalebo, 2002).Particle size distribution was determined by hydrometer method using calgon solution as dispersing agent. The soil pH was measured with a glass pH electrode after 1.1 soil/ water ratio suspension. The organic carbon content was determined by the modified wet oxidation method of Wilkey and Black and converted to organic matter by multiplying by 1.724. Total nitrogen was determined by the micro-Kjeldahl digestion and distillation method. Available phosphorus was determined by the Bray 1Acid Fluoride solution. Exchangeable cations were extracted with 1.1 ml Ammonium acetate at pH 7. Na and K were measured with flame photometer while Ca and Mg were measured with atomic absorption spectrophotometer. Cation exchange capacity was measured by Ammonium acetate technique.

c) Land preparation and field method

The experimental site was cleared manually and the size of each sub plot was 3.0 X 3.0 (9 m2), with an inter-plot space of 0.5 m.). The experimental design was laid out in a randomized complete block design (RCBD) with three replications. The treatments used were:

1. Control
2. 100 % NPK 15-15-15
3. 100 % Moringa leaves (MO)
4. 100 % Poultry manure (PM)
5. 50% Moringa leaves (MO) + 50% NPK
6. 50% Moringa leaves (MO) + 50% Poultry manure (PM)

The chemical composition of moringa leaves (MO) and poultry manure used in the study is given in in Table 1. All the treatments except the control were applied at the rate of 60 kg N/ha as recommended by Aduloju and Abdulmalik (2013) for the optimum growth of maize.

© 2018 Global Journals

Table 1: Proximate analysis of moringa leaves and poultry manure

Nutrient element	N (%)	P(%)	K(%)	OC(%)	Ca(%)	Mg(%)	Fe(%)	Zn(%)
Moringa leaves	2.56	0.22	1.13	68.9	0.84	0.29	201.0	31.45
Poultry manure	1.14	0.41	2.06	62.5	1.83	0.93	3560.0	32.85

The fertilizers were applied to the variety of BR9928 DMR –SR (Yellow, Downy Mildew Streak Resistance) maize. The planting distance was 75 cm x 25 cm at two plants / stand. However, maize plant was later thinned to one after seedling emergence. The organic fertilizer sources were applied two weeks before planting to allow for their mineralization while the mineral fertilizer was applied two weeks after planting. Collection of data commenced from 4, followed by 8 weeks after planting till the twelfth weeks. Maize was harvested fresh at 12 WAP. Growth and yield parameters measured were; plant height, stem girth, number of leaves, leaves area, and grain yield. Plant height was measured with a meter rule at the distance from soil level to the terminal bud, leaf area determination was derived from the length and breadth measurement of the longest leaf per plant and a correction factor value of 0.75 were used to multiply the value following the procedure of Okonmah, (2012). Number of leaves was by visual counting of the leaves, plant girth was measured with vernier calipers at 3 cm above soil level. The yield was determined by measuring cob weight, dry grain weight of 100 grains. Data collected were subjected to Statistical Analysis System (SAS) for Analysis of variance (ANOVA) and the treatments were compared at 5 % level of significance using the Duncan's Multiple Range Test (DMRT). Net income of maize under different treatments was used to compare the economics of the treatments.

III. Results and Discussion

Table 1 shows the mineral content of Moringa leaves and poultry manure. From the analysis, there is an indication that both the poultry manure and leaves of Moringa have high content of macro- and micro-elements.

The initial soil physico-chemical properties of the studied area are shown in Table 2.The soil is of sandy loam textural class with 69.4% sand, 24.4% silt and 6.2% clay. Slightly acidic with pH of 6.5. The pH of most agricultural soils in tropics has been reported to range from 5.0 to 6.8 (Udo and Ogunwale, (1977).The organic matter content as well as the total nitrogen and available phosphorus are low, indicating that the soil is will respond positively to fertilizers applied to improve maize productivity.

In 2016, maize plant height was significantly influenced by application of moringa leaves when combined with NPK fertilizer. At 4, 8 and 12 WAP, maize plant in the MOR+NPK treatment was taller than those of other treatments by 11-45%, 12-55% and 8-31%, respectively. The control treatment consistently produced the shortest plant height. In 2017, Maize plant height also differed significantly ($P < 0.05$) among the fertilizer treatments (Table 3). Percentage differences observed in maize plant height in 2016 at the different sampling intervals were also maintained in 2017. Likewise, the application of MOR+NPK treatment was better than the use of NPK (15:15:15) alone. This is in line with the results of Olowoake *et al*. (2015) who reported that the combinations of organic and mineral fertilizer perform better on plant height than when each of them is solely used.

Table 2: Physico-chemical properties of experimental soil

Parameters	Soil test value
pH(H_2O)	6.5
EC (dS/.m)	0.3
Org.C(gk/g)	8.76
Total N(g/kg)	0.7
P (mg/kg)	9.7
Exchangeable bases c mol/kg	
Mg	4.54
Ca	2.34
Na	16.19
K	0.41
Extractable micronutrients	
Cu	45.5
Fe	35,75
Mn	70.5
Zn	377.5
Textural class %	
Sand	69.4
Silt	24.4
Clay	6.2
Textural class	Sandy loam

© 2018 Global Journals

Table 3: Maize plant height (cm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks After Planting (WAP)		
	4	8	12
	2016		
Control	20.8d	43.1d	89.9d
MOR	33.9b	85.5b	111.3b
PM	25.5c	59.1c	108.7c
MOR+NPK	37.9a	96.8a	130.8a
MOR+PM	31.9b	63.1b	99.4c
NPK	30.0b	65.2b	119.7b
	2017		
Control	10.29c	50.0d	63.5d
MOR	16.4b	61.3c	66.0c
PM	18.0a	68.5c	73.0b
MOR+NPK	18.7a	94.0a	104.0a
MOR+PM	17.2b	81.9b	90.5a
NPK	16.6b	60.3c	77.0b

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

In 2016, the number of leaves per plant differed significantly ($P< 0.05$) among the different fertilizer treatments (Table 4). At 4 WAP, NPK treatment had 3-19% more number of leaves per plant than others while at 8 and 12 WAP, MOR+NPK had 6-26% and 12-18% number of leaves than others. All the fertilized plots had higher number of leaves per plant than the control treatment. The number of leaves per plant also differed significantly ($P< 0.05$) among the fertilizer treatments in 2017 (Table 4). At 4 WAP, there were no significant differences ($P< 0.05$) on number of leaves for plot treated with MOR+NPK and NPK. Likewise, Sole application of NPK fertilizer was not statistically better than the combined use of moringa leaves and NPK in terms of number of leaves. However, at 12 WAP, the higher number of leaves produced from organomineral MOR+NPK over the NPK throughout the growing period could be due to sustaining release of nutrients from the former over the latter (Ogundare *et al*., 2012; Ndaeyo *et al*., 2013).

Table 4: Number of leaves of maize plant as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks After Planting (WAP)		
	4	8	12
	2016		
Control	5.9c	8.2d	9.7c
MOR	6.8b	10.4b	11.0b
PM	6.4b	8.7c	10.5b
MOR+NPK	7.1a	11.1a	11.9a
MOR+PM	6.6b	9.9b	11.3b
NPK	7.3a	9.9b	11.0b
	2017		
Control	5.0b	9.0c	10.0d
MOR	5.5a	11.5b	13.0b
PM	6.0a	12.0a	12.0c
MOR+NPK	6.5a	13.0a	14.0a
MOR+PM	6.0a	11.6b	12.5b
NPK	6.0a	11.0b	12.0b

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

© 2018 Global Journals

In 2016, maize plant stem girth at 4, 8 and 12 WAP differed significantly (Table 5) among the different fertilizer treatments. Stem girth in the MOR+NPK plot was bigger than in other treatments at 4, 8 and 12 WAP by 14-40%,14- 42% and8-39%respectively. The smallest stem girth was produced by the control treatment. In 2017, maize plant stem girth differed significantly ($p<0.05$) among fertilizer treatments in (Table 5) with the trend observed in 2016 maintained in 2017. The application of MOR+NPK resulted in the production of maize plant with bigger stem girth while the control consistently had the smallest stem girth. The significance increases ($p<0.05$) in stem girth of all the treatments compared with control attest to the ability of these treatments in supplying plant nutrients. The increase in stem girth had been claimed to be as a result of better nutrient mineralization with time of application(Gobron, 2009).

Table 5: Stem girth of maize plant (mm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks After Planting (WAP) 4	8	12
		2016	
Control	4.3d	7.7d	8.3d
MOR	6.2b	10.1c	10.8 c
PM	5.4c	11.0b	11.3b
MOR+NPK	7.2a	13.2a	13.7a
MOR+PM	5.9b	10.0c	10.4c
NPK	5.3b	11.4b	12.6b
		2017	
Control	4.0d	7.5d	8.0d
MOR	5.5c	11.5c	12.0c
PM	6.0b	12.0b	12.5c
MOR+NPK	7.0a	13.8a	15.0a
MOR+PM	6.3b	12.1b	13.1b
NPK	6.0b	12.0b	13.6b

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

Table 6 shows that at 4, 8 and 12 WAP, the leaf area of maize plant differed significantly($p<0.05$) among the different fertilizer treatments in 2016. The leaf area in the MOR+NPK plot was larger than other treatments at 4, 8 and 12 WAP by 9-56%, 13-56% and 6- 42% respectively. The control treatment produced the smallest leaf area. Maize plant leaf area was significantly ($p<0.05$) influenced by the fertilizer treatments in 2017 (Table 6). The MOR+NPK treatment produced the widest leaves and exhibited the same pattern observed in 2016 while the control treatment had the smallest leaf size. Generally, the MOR+NPK treatment produced bigger leaves area than mineral fertilizer (NPK). This implies that, higher availability of N, P and K were important for leaf growth of maize. This result is similar to the findings of Gobron, (2009). Increasing NPK fertilizer rate probably increased the photosynthetic activity and leaf area. The values of maize plant leaves area were observed to below in the entire plot without any fertilizer treatment when compared to moringa leaves enriched with either poultry manure or NPK fertilizer treatments. This might be as a result of low nutrients status of the soil especially N and P.

© 2018 Global Journals

Table 6: Leaves area of maize plant (mm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

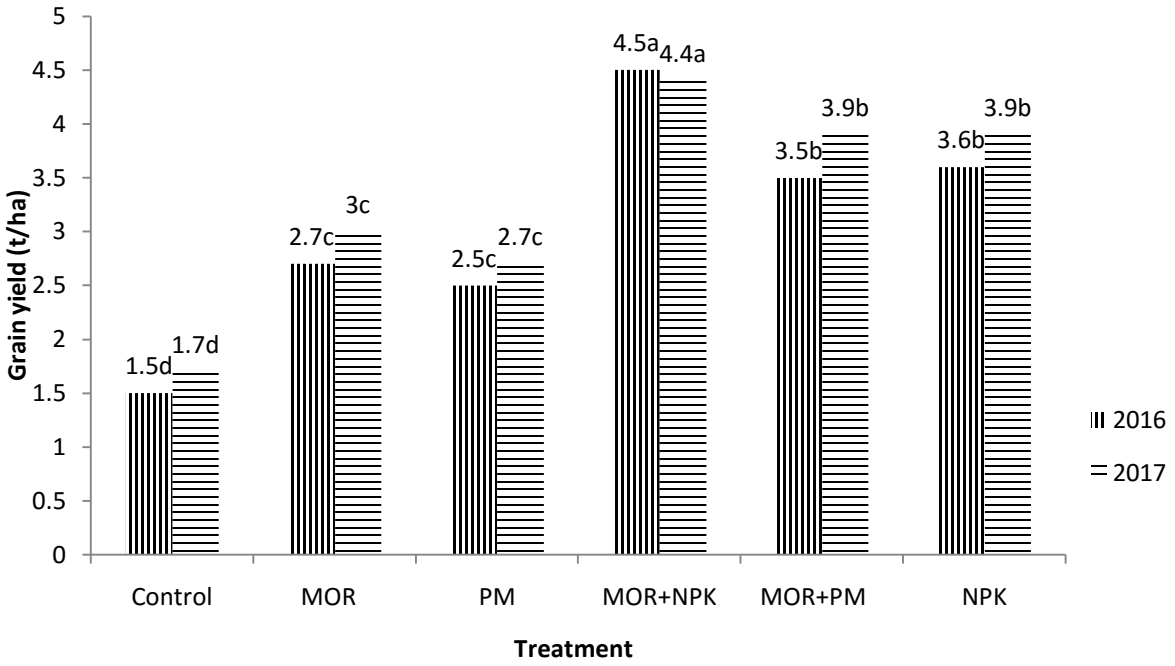
Treatment	Weeks After Planting (WAP) 4	8	12
		2016	
Control	65.9e	85.4e	147.6e
MOR	136.3b	167.8b	193.0c
PM	78.7d	96.8d	164.9d
MOR+NPK	149.1a	192.1a	254.9a
MOR+PM	123.7c	130.7c	154.2d
NPK	119.7c	164.1c	239.8b
		2017	
Control	48.9d	116.8e	150.0d
MOR	67.6c	125.6c	168.9c
PM	110.7a	160.3b	190.0b
MOR+NPK	106.9a	192.2a	202.4a
MOR+PM	76.5c	126.0c	187.1b
NPK	106.3b	123.4d	174.5c

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

Figure 1 shows that, the maize grain yield differed significantly ($p<0.05$) among the different fertilizer treatments in 2016 and 2017. The MOR+NPK treatment produced the highest total grain yield (4.5 t/ha and 4.4 t/ha in 2016 and 2017 respectively) while the control had the least grain yield (1.5 t/ha and1.7 t/ha, in 2016 and 2017 respectively). The MOR+NPK treatment produced 20–67% and 11-61%more grain yield than other treatments in 2016 and 2017, respectively. There was no significant ($p<0.05$) difference between grain yield produced from the MOR+ PM and NPK in 2016 and 2017, respectively. The maize plants without fertilizer treatment had the lowest yield which could have been partly due to deficiency of nutrients as revealed by low nutrient status of the soil from the initial physic-chemical analysis. This agrees with statement by FAO, (2013) that increment in maize production occurred with higher levels of fertilizer application. The higher grain yield produced from combination of moringa leaves and mineral fertilizer was similar to the works of Olowoake and Ojo (2014); Nwaogu, (2013); Ogunlade *et al*., 2011 who reported that the combinations of organic and mineral fertilizer perform better on the yield of Amaranthus caudatus and maize, than when each of them is solely used.

© 2018 Global Journals



Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Fig. 1: Maize Grain yield (t/ha) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

The effectiveness of any production is eventually estimated on the basis of its economic returns. Table 7 showed that higher net benefit (₦143, 500) was obtained with the application of MOR+NPK followed by the net benefit (₦ 117,000) obtained with NPK and minimum net benefit (₦ 28,000) was recorded in control. The economic returns analysis between 2016 and 2017 indicated higher netrevenues on the maize plot with MOR+NPK treatments than other plots. The supply of a more balance proportion of essential nutrients by NPK and moringa leaves could account for its highest return. According to Kombat (2015), balanced and adequate fertilizer application is essential for increasing crop yields and net returns, whiles ensuring sustainability.

Table 7: Estimates of cost and returns of maize under different treatments in 2016 and 2017

Treatment	Mean yield (t /ha)	Mean revenue per maize treatment₦	Variable cost ₦	Fixed cost ₦	Total cost ₦	Net farm income ₦
Control	1.6	64,000	28,000	8,000	36.000	28,000
MOR	2.9	114,000	44,000	8,000	52,000	62,000
PM	2.6	104,000	31,000	8,000	39,000	73,000
MOR+NPK	4.5	178,000	34,500	8,000	42,500	143,500
MOR+PM	3.7	148,000	33,000	8,000	41,000	115,000
NPK	3.8	150,000	33,000	8,000	33,ooo	117,000

Average 1 USD is approximately ₦306.3 (as at December 2017)

IV. Conclusion

This study showed that moringa leaves supplemented with NPK at 60 kg N/ha gave the best performance in all the growth and yield parameters. The study has also demonstrated that application of NPK alone performed better than the poultry manure and moringa alone in terms of grain yield. However the use of organic moringa leaves in combination with mineral fertilizer (MOR+NPK) can sustain maize production.

© 2018 Global Journals

Also, it was more economical to apply the combination of organic and inorganic fertilizer for maize production in Ilorin, guinea savannah zone of Nigeria.

Acknowledgment

The authors are grateful to Tertiary Education Trust Fund (TETFUND), the Management of Kwara State University, Malete, Ilorin, Nigeria, for providing the fund for conducting this research.

References Références Referencias

1. Adebayo, A.G., Akintoye, H.A., Olufolaji O.O., Aina, M.T., Olatunji, M.T. and Shokalu, A.O. (2011). Assessment of organic amendments on vegetative development and nutrient uptake of *Moringa oleifera* Lam in the nursery. Asian J. Plant Sci. 10(1):74-79.
2. Adeniyan, O.N. and S.O. Ojeniyi, (2005). Effect of organic manure, NPK 15 – 15 -15 and combination of their reduced levels on maize growth and soil chemical properties. Niger. J. Soil Sci., 15: 24-41.
3. Aduloju, M. O. and Abdulmalik, T. O. (2013). Effect of Zinc and N-P-K application on Phosphorus and Zinc uptake by maize (*Zea mays* L.) on an Alfisol. Global Journal of Bioscience and Biotechnology 2(4): 496-499.
4. Agbede, T. M. (2010). Tillage and fertilizer effects on some Soil properties, leaf nutrient concentrations, growth and sweet potato yield on an Alfisol in southwestern Nigeria. Soil Tillage Res. 110:25–32.
5. Anwar, F., Latif, S., Ashraf M. and Gilani A. H. (2007). *Moringa oleifa:* A food plant with multiple medicinal uses. Phytother. Res. 21:17-25.
6. Daramola, D. S., and Taiwo, L. B. (2008). Effects of equvalent replacements of inorganic N with organic N on the growth and N uptake of maize (Zea mays).Moor Journal of Agricultural Research. 9: 26-34.
7. Food and Agriculture Organisation of the United Nations (FAO). (2003). Fertilizer and the future IFA / FAO Agricultural conference on Global food security and role of sustainability. Fertilization Rome, Italy 16th - 20th March 2003 Pp 1- 2.
8. Fuglie, L. J. (2000). The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the Tropics. The multiple Attributes of Moringa. p 172.
9. Gobron N. (2009). Leaf Area Index ftp:/ftp.fao.org/docrep/fao/OI110197e/i0197e15.pdf.
10. IITA. (2001). Annual report on maize production by International Institute of Tropical Agriculture, Ibadan, Nigeria. pp 50. old.iita.org/cms/articlefiles/275-IITA_AR_2001.pdf. Accessed 04/02/2015.
11. Ikpe, F. N. and J. M. Powel (2002).Nutrient Cycling Practices and Changes in Soil Properties in the Crop-Livestock Farming Systems of Western Nigeria, West Africa. Nut. Cyc. Agro-ecosystem. 62:37-45.
12. Kombat, R. K. (2015). Effect of four NPK fertilizer formulations and their application rates on growth and yield of maize *(Zea mays* L.) in the Guinea Savannah Agroecology of Ghana. MSc. Thesis, Department of Agronomy University for Development Studies, Ghana. 97pp.
13. Law-Ogbomo, K. E., Remison, S. U. and Jombo, E. O. (2011).Effects of organic and inorganic fertilizer on the productivity of Amaranthus cruentus in an ultisol environment. International Journal of Plant Physiology and Biochemistry 3 (14):247 - 252.
14. M. O. Ogunlade, E. A. Adeyemi, D. O. Ogunleti, and P. S. Ibiyomi, "Effect of cocoa pod husk, urea fortified cocoa pod husk and NPK fertilizers on the growth and yield of *Solanummacrocarpon* cultivation, International Journal of Organic Agriculture Research and Development, vol. 3, pp. 1–8, 2011.
15. Mvumi, C., Tagwira F. and Chiteka, A. Z. (2013). Effect of moringa extract on growth and yield of maize and common beans. Greener J. Agri. Sci., 3(1): 55-62.
16. Ndaeyo, N. U., Ikeh, A. O., Nkeme, K. K., Akpan, E. A. and Udoh, E. I. (2013).Growth and Foliar Yield Responses of Waterleaf (Talinumtriangulare Jacq) to Complementary Application of Organic and Inorganic Fertilizers in a Ultisol, American Journal of Experimental Agriculture, 3(2): 324-335.
17. Nwaogu, E. N. (2013). Effects of Organo-mineral Fertilization on Nitrogen, Yield and Yield Sustainability Responses of Maize in Rainforest Ecology of South Eastern Nigeria. *International* Journal of Applied Research and Technology. 2(3): 84 – 93.
18. Ogundare, K., Agele, S and Peter Aiyelari (2012). Organic amendment of an ultisol: effects on soil properties, growth, and yield of maize in Southern Guinea savanna zone of Nigeria. International Journal Of Recycling of Organic Waste in Agriculture 1:11.
19. Ogunsumi, L. O., Ewuola, S. O. and Daramola, A. G. (2005). Socio-Economic Impact Assessment of Maize Production Technology on Farmers' Welfare in South West, Nigeria. J. Central Eur. Agric, *6*(1): 15-26.
20. Ojeniyi, S. O. (2000). Effect of goat manure on soil nutrient and okra yield in a rainforest area of Nigeria. Appl Trop Agric. 5: 20–23.
21. Ojeniyi, S.O and Adegboyega, A. A. (2003).Effect of combined use of urea and goat manure dung on Celosia.Nigeria Agriculture Journal 34: 87-90.
22. Okalebo, J.R., K.W. Gathua, and P.L. Woomer. (2002). Laboratory method of soil and plant analysis: A working manual. 2nd Edition. TSBF-CIAT and SACRED Africa, Nairobi, Kenya.

© 2018 Global Journals

23. Okonmah, L. U (2012) effects of various organic manure on the growth and yield of maize in Asaba Agro–Ecological zone. Asian journal of science and technology vol. 4, issue, 11, pp. 006-009.
24. Olowoake, A. A.andOjo, J.A.(2014). Effect of fertilizer types on the growth and yield of *Amaranthus caudatus* in Ilorin, Southern Guinea Savanna Zone of Nigeria. Advances in Agriculture, vol. 2014, Article ID947062, 5 pages.
25. Olowoake A. A. (2017).Nutrient Release Pattern from Compost Supplemented with Jatropha Cake on Alfisol of Ilorin, Nigeria. International Journal of Plant and Soil Science 15(5): 1-11.
26. Olowoake, A.A (2014). Influence of organic, mineral and organomineral fertilizers on growth, yield and soil properties in grain amaranth (*amaranthus-cruentus.* L) Journal of organics 1 (1): 39-47.
27. Olowoake, A.A., Ojo J.A. and Osunlola, O.S. (2015).Growth and yield of okra (*Abelmos-chusesculentus* L.) as influenced by NPK, jatropha cake and organomineral fertilizer on an Alfisol in Ilorin, Southern Guinea Savanna of Nigeria. Journal of Organic Systems, 10(1): 3-8.
28. Otitoju, O. M., M. B. Adewole, A. A. Olowoake and A. O. Ilesanmi (2016). Direct and Residual Effects of Different Poultry Compost and NPK Fertilizer Applications on Drought-Tolerant Maize Production. Journal of Sustainable Development 9 (4): 61-69.
29. Phiri, C. (2010). Influence of *Moringa oleifera* leaf extracts on germination and early seedling development of major cereals. Agric. Biol. J. Am. 1(5):774-777.
30. Russo A., Carrozza G. P., Vettori L., Felici C., Cinelli F. and Toffanin A. (2012). Plant Beneficial Microbes and Their Application in Plant Biotechnology. Innovation in Biotechnology. Dr. Eddy C Agbo (Ed), ISBN: 978-956-51-0096-6, In Tech. pp. 57-72.
31. Soremi A. O., M. T. Adetunji, J. O. Azeez, C. O. Adejuyigbe and J. G. Bodunde (2017). Speciation and dynamics of phosphorus in some organically amended soils of southwestern Nigeria, Chemical Speciation and Bioavailability, 29 (1): 42-53.
32. Sridhar M. K. C. and Adeoye, G. O. (2003). Organomineral fertilizer from urban wastes. The Nigerian Field, 68: 91–111.
33. Udo, E. J., and Ogunwale, J. A. (1977). Phosphorus fractions in selected Nigeria soils. Soil Science Society of America Journal.; 46:1141–1146.
34. Yang, R.Y., Chang, L. C., Hsu, J. C., Weng, B. B. C., Palada, M. C., Chadha, M. L. and Levasseur, V. (2006). Nutritional and Functional Properties of *Moringa* leaves-from germplasm, to plant, to food, to health. In: Proceedings of the International Workshop "*Moringa* and other highly nutritious plant sources: strategies, standards and markets for a better impact on nutrition in Africa, Accra, Ghana pp. 1-9.

© 2018 Global Journals

This page is intentionally left blank

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Technological Strategy for Diagnosis of Phenological Damage in Wheat Crops

By Silvia Soledad Moreno Gutiérrez, Alfredo Toriz Palacios, Sócrates López Pérez & Abraham Sánchez López

Autonomous University of the State of Hidalgo

Abstract- An analysis of damage caused by climate change on the wheat crop in each of its stages of development was carried out, for this, a Backpropagation Artificial Neural Network and an analysis module for the permanence of climatic conditions were used, ten variables were used meteorological and 68685 daily records from various regions of the world, using 79% for training and 21% to validate the network. Regarding the analysis of the damage by stage of development in function of the climate, that is to say, of fenológico damage, the criteria proposed by the Organization of the United Nations for the Feeding and the Agriculture (FAO) and the scale Zadoks were considered. The technological strategy reached an accuracy of 84%, making it suitable for diagnosing phenological damage in the wheat plant, and constitutes an alternative to strengthen sustainable adaptation strategies and food security.

Keywords: *artificial neural networks, phenological damage, wheat, technological strategy, climate change.*

GJSFR-D Classification: *FOR Code: 070199*

Strictly as per the compliance and regulations of:

© 2018. Silvia Soledad Moreno Gutiérrez, Alfredo Toriz Palacios, Sócrates López Pérez & Abraham Sánchez López. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons. org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Technological Strategy for Diagnosis of Phenological Damage in Wheat Crops

Estrategia Tecnológica Para Diagnóstico De Daño Fenológico En Cultivos De Trigo

Silvia Soledad Moreno Gutiérrez [α], Alfredo Toriz Palacios [σ], Sócrates López Pérez [ρ] & Abraham Sánchez López [ω]

Resumen- Se realizó un análisis dedaño ocasionado por el Cambio Climático sobre el cultivo de trigo en cada una de sus etapas de desarrollo, para ello, se empleó una Red Neuronal Artificial Backpropagationy un módulo de análisis de permanencia de condiciones climáticas, se emplearon diez variables meteorológicas y68685 registros diarios provenientes de diversas regiones del mundo, empleando el 79% para entrenamiento y el 21% para validar la red. Respecto al análisis del daño por etapa de desarrollo en función del clima, es decir, de daño fenológico, se consideraron los criterios propuestos por la Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO)y la escala Zadoks. La estrategia tecnológica alcanzó una precisión del al 84%, por lo que es adecuada para diagnosticar daño fenológico en la planta de trigo, y constituye una alternativa de fortalecimiento a las estrategias de adaptación sustentables y a la seguridad alimentaria.

Palabras clave: redes neuronales artificiales, daño fenológico, trigo, cambio climático.

Abstract- An analysis of damage caused by climate change on the wheat crop in each of its stages of development was carried out, for this, a Backpropagation Artificial Neural Network and an analysis module for the permanence of climatic conditions were used, ten variables were used meteorological and 68685 daily records from various regions of the world, using 79% for training and 21% to validate the network. Regarding the analysis of the damage by stage of development in function of the climate, that is to say, of fenológico damage, the criteria proposed by the Organization of the United Nations for the Feeding and the Agriculture (FAO) and the scale Zadoks were considered. The technological strategy reached an accuracy of 84%, making it suitable for diagnosing phenological damage in the wheat plant, and constitutes an alternative to strengthen sustainable adaptation strategies and food security.

Keywords: artificial neural networks, phenological damage, wheat, technological strategy, climate change.

Author α σ: Universidad Popular Autónoma del Estado de Puebla.
e-mail: silviasoledad.moreno@upaep.edu.mx
Author ρ: Universidad Autónoma del Estado de Hidalgo.
Author ω: Benemérita Universidad Autónoma de Puebla.

I. Introducción

A nivel internacional el trigo es considerado alimento clave para la supervivencia humana y forma parte de la dieta básica, se ubica en el segundo lugar mundial por su producción y consumo (Reynolds et al., 2016), debido a que muestra un fuerte impacto sobre la seguridad alimentariay el desarrollo económico mundial, el trigo representa un cultivo prioritario.

Al mismo tiempo, como consecuencia de la época moderna y su industrialización (Serrano, 2015), y con ello el incremento de gases efecto invernadero (Sapkota et al., 2015), el fenómeno conocido globalmente como Cambio Climático (CC), de unas décadas a la fecha, ha significado drásticos incrementos en la temperatura global (Singh y Singh, 2015), fuertes cambios en los patrones meteorológicos y grave impacto sobre la agricultura según Basche, et al., (2016), debido a la cercana relación existente entre el desarrollo del cultivo y las condiciones climatológicas favorables (Reeves, Thomas y Ramsay, 2016). Según estudios efectuados por Iizumi y Ramankutty (2016), la variabilidad del rendimiento de cultivos de cereal básico, en un 21% ha sido consecuencia de la presencia de temperaturas extremas, generalmente altas, encontrándose el trigo (Triticum aestivum L.) entre una de las especies más afectadas (Jones y Phillips, 2016).

El CC ha significado volatilidad de precios e incremento de las importaciones de cereal básico (Butt et al., 2016),la proyección de su rendimiento al año 2050, expone un escenario desolador, donde el trigo aparece como uno de los cereales cuyo rendimiento disminuirá drásticamente, ya que las temperaturas continuaran incrementando (Torres, 2017), el déficit de trigo provocará reducción de la ingesta calórica diaria (Tesfaye et al., 2015), presión demográfica en sistemas de alimentos (Massawe, Mayes y Cheng, 2016), en caso de no contar con estrategias de adaptación eficaces (ver figura 1), no obstante, la demanda continuará incrementando al año 2030 (ver figura 2).

© 2018 Global Journals

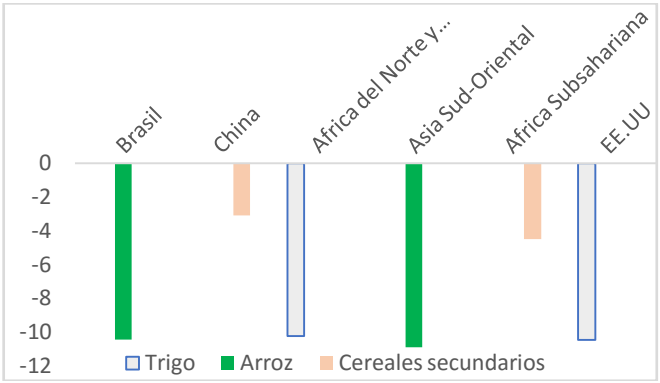


Figura 1: Disminución proyectada del rendimiento de cereales debido al CC en el año 2050, sin adaptación (%). Fuente: elaboración propia con datos de Reeves, Thomas y Ramsay (2016)

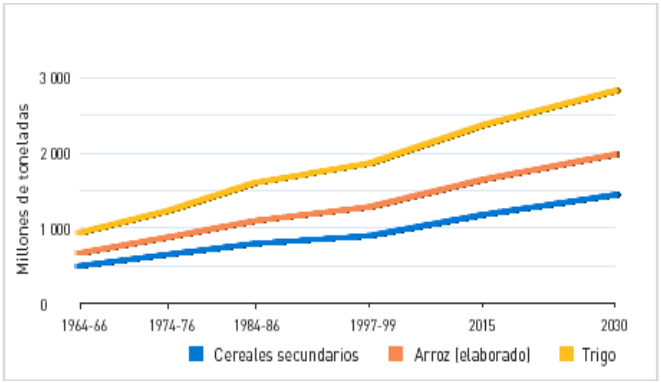


Figura 2: Tendencias de demanda mundial de cereales. Fuente: FAO. Agricultura mundial: hacia los años 2015/2030. Informe resumido (2002)

En la búsqueda de alternativas que apoyen al sector cerealista a reducir las pérdidas económicas y de cultivos, así como la vulnerabilidad de sus cultivos de trigo ante la variabilidad climática, ha llevado a cabo diversos trabajos de investigación, así como múltiples desarrollos tecnológicos, que contribuyan a enfrentar con eficiencia y eficacia el reto del CC y a mantener los niveles óptimos de producción.

La literatura revisada expresa el trabajo relacionado, no obstante, en el presente apartado se mencionan únicamente las propuestas de mayor representatividad.

a) Modelos de Simulación de Cultivos, son sistemas de software capaces de analizar comportamientos posibles del cultivo, algunos de mayor uso son:

- CERES en trigo (Gallo, 2015), inadecuado en algunos casos pues requiere grandes cúmulos de información (Zheng, Cai, Yu y Hoogenboom, 2017) e inadecuado al simular altas temperaturas (Gaydon et al., 2017).
- El Simulador de Sistemas de Producción Agrícola APSIM con resultados satisfactorios, requiere ajustes para países asiáticos (Gaydon et al., 2017).

b) Modelos fenológicos y predictivos, son capaces de obtener información del impacto del CC sobre el desarrollo fenológico del cultivo, sin embargo, han sido analizados concluyendo deficiencias al representar altas temperaturas (Asseng et al., 2015), además de enfoques únicamente locales (Arnell, 2016).

c) Sistemas inteligentes. Las técnicas de Inteligencia Artificial han participado en el apoyo al sector cerealista expone Barrero et al., (2016), sobre todo en la clasificación y predicción a través de las Redes Neuronales Artificiales (RNA), considerada como la técnica de mayor preferencia en el sector, que ha mostrado superioridad predictiva sobre las técnicas tradicionales (Tripathi,2015; Mansourian et al., 2017, Lv et al., 2015), aun cuando el sector del cereal cuenta con modelos inteligentes para evaluar el crecimiento del trigo bajo estrés por calor y considera (Boutraa et al., 2015; Ihsan et al., 2016; Sanad et al., 2016), en la construcción de modelos fenológicos, las técnicas matemáticos estadísticas, constituyen las de mayor preferencia.

Por otra parte, el sector del cereal, también ha efectuado diversas investigaciones orientadas a analizar el efecto del CC sobre cada una de las etapas fenológicas de la planta de trigo, logrando identificar aquellas de mayor resistencia y sensibilidad, a las heladas (Crimp, 2016; Frederiks et al., 2015), a las bajas temperaturas (Ji et al., 2017), así como a las temperaturas altas(Pimentel et al., 2015), por mencionar algunos, siendo la antesis la etapa más sensible(Chen et al., 2017).

A pesar de las diversas propuestas tecnológicas e investigaciones realizadas, la literatura expresa ausencia de propuestas con enfoque global, de alta precisión que apoyen la toma de decisiones del agricultor a través de la evaluación del desarrollo de sus cultivos de trigo, no se observan herramientas centradas en el monitoreo de cada etapa fenológica, en correspondencia con los factores climáticos presentes, siendo esta una actividad clave para la identificación oportuna de daño y con esto para la reducción de pérdidas y mejoramiento de la producción.

Por lo anterior, el documento expone una estrategia tecnológica que analiza el desarrollo fenológico del trigo, según su etapa y es capaz de efectuar diagnóstico de daño en caso de que las condiciones climáticas superen los umbrales soportados por la planta de trigo para un desarrollo favorable. La RNA se apoya en un modelo Backpropagation, con un enfoque global, que contribuye a reducir la incertidumbre relacionada con el desarrollo del trigoante el CC, constituyendo una guía para el agricultor en los procesos de planeación de cultivos.

© 2018 Global Journals

II. Metodología

Estrategia tecnológicapara diagnóstico de daño fenológico en cultivos de trigo

La estrategia se compone principalmente de una RNA de tipo Backpropagation, seguida de un bloque de resultados. La red evalúa el desarrollo del cultivo y en caso de presentarse condiciones climáticas adversas, podría diagnosticar daño fenológico, el bloque de análisis de permanencia de condiciones climáticas permite la interacción con el usuario quien ingresará datos meteorológicos para proceder a su evaluación (ver figura 3).

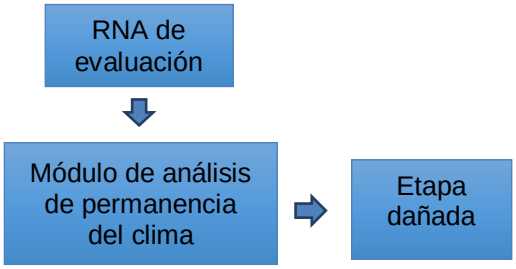


Figura 3: Estrategia tecnológica de diagnóstico de daño fenológico. Fuente: elaboración propia

a) *RNA*

Una RNA se refiere a un conjunto de nodos interconectados conocidos como neuronas, que tienen como propósito lograr el aprendizaje de un cúmulo de datos y su comportamiento, mediante la implementación de algoritmos de aprendizaje, los cuales se basan en los principios de las redes neuronales biológicas. Cada nodo cuenta con uno o más datos de entrada, que serán procesados para la obtención de un valor de salida, el cual será evaluado mediante la función de activación apropiada (Yegnanarayana, 2009).

i. *Arquitectura*

La RNA se desarrolló con base en un modelo multicapa Backpropagation que cuenta con 10 variables de entrada, cada una coincide con un factor climático: Temperatura media T (°C), Temperatura máxima TM (°C), Temperatura mínima Tm (°C), Humedad relativa media H (%), Precipitación total de lluvia PP (mm), Visibilidad media VV (Km), Velocidad media del viento V (Km/h), Velocidad máxima sostenida del viento VM (Km/h), Indicador de lluvia o llovizna RA e Indicador de niebla FG.

La RNA propuesta es de 32-20-8 neuronas, respectivamente en cada una de sus capas. Como se observa en la figura 4, el total de salidas son 8 y cada una corresponde a cada etapa fenológica del trigo, cuya salida será 1 en caso de daño y -1 en caso contrario.

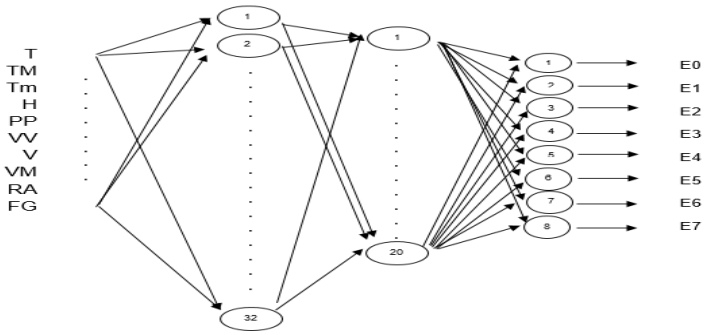


Figura 4: Arquitectura de la RNA. Fuente: elaboración propia

ii. *Consideraciones para el diagnóstico de daño fenológico*

La identificación de daño en la planta se basa en la propuesta emitida por la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), correspondiente a situaciones problemáticas del cultivo de trigo ante el CC (Rawson y Macpherson, 2001), los factores climáticos que han sido considerados debido a que pueden detener o dañar el desarrollo son: estrés hídrico, temperaturas fuera de los márgenes óptimos, radiación solar baja, lluvias y vientos fuertes.

En daño por estrés hídrico, considera la temperatura media, calcula el coeficiente de evapotranspiración según la etapa fenológica, identificando el número de días sin riego ni lluvia significativa sobre el cultivo antes de sufrir estrés, en la propuesta se expresa el daño 7 días antes de que este suceda.

En cuanto a daño por variación de temperaturas, se analiza la temperatura base y la temperatura óptima, según umbrales expresados por Rawson y Macpherson, (2001), como se muestran en la figura 5, siguiente.

© 2018 Global Journals

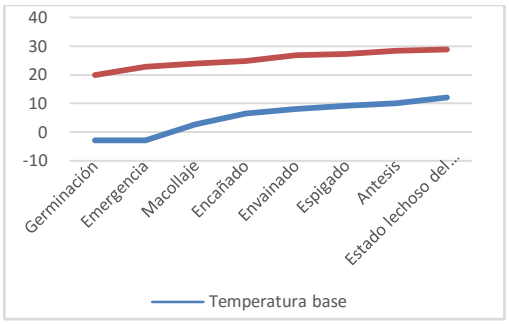


Figura 5: Temperatura base y temperatura óptima por fase de desarrollo (°C) del trigo. Elaboración propia con datos de Rawson y Mcpherson (2001).

La baja radiación solar es diagnosticada al presentarse altas temperaturas (superiores a los valores soportados por la planta en su etapa de desarrollo) y tiempo nublado.

La presencia permanente de lluvia o llovizna, así como de vientos fuertes, con base en la escala de Beaufort de 50 a 61 km/h (García et. al., 2014), también se considera causal de daño fenológico.

Cada etapa responde diferente al clima, generalmente después de varios días consecutivos de experimentar condiciones climáticas adversas, el número de días soportados difiere según la etapa y el factor climático. La pérdida de rendimiento puede considerarse hasta de un 4% por cada °Cque incremente la temperatura media sobre la temperatura óptima. En el análisis del desarrollo de la planta, fueron consideradas las etapas siguientes: Germinación, Emergencia, Macollaje, Encañado, Envainado, Espigado, Antesis, Estado lechoso del grano, Estado pastoso del grano y Madurez, según escala Zadoks (Rawson y Macpherson, 2001), en ambiente húmedo, subhúmedo, semiárido y árido.

Tabla 1: Factores de daño por etapa fenológica del trigo

Etapa fenológica	Factores de daño
Germinación	H, EH, T
Emergencia	H, EH, T
Macollaje	H, EH, T, BRS
Encañado	EH, T, BRS
Envainado	EH, T, BRS
Espigado	EH, T, BRS
Antesis	EH, T, BRS, LI, VF
Estado lechoso del grano	EH, T, BRS

Causas relacionadas con factores meteorológicos. EH Estrés hídrico, T temperaturas, H Heladas, BRS Baja Radiación Solar, LI Lluvia, VFViento fuerte. Fuente: Rawson y Macpherson (2001).

iii. *Aprendizaje*

En el proceso de aprendizaje se empleó el algoritmo de tipo Backpropagation, su funcionamiento de manera general consiste en el aprendizaje de un conjunto de duplas entrada-salida determinadas, posteriormente un ciclo de propagación-adaptación en dospartes:

1) Seaplica el patrón de entrada como estímulo a la primera capa de neuronas, se propaga hacia adelante hasta llegar a lacapa de salida y obtener un resultado que será comparado con salida deseada. La diferencia entre ambos valores, para cada una de las neuronas, constituye el error.
2) El error propagan hacia atrás, partiendo de la capa de salida a la capa intermedia en cada una de sus neuronas.

El proceso se repite, por cada capa y cada neurona hasta que todas hayan recibido un error, el cual describirá su aportación al error total, con base en cada error, se actualizan los pesos de cada neurona Yegnanarayana (2009).

© 2018 Global Journals

a. *Algoritmo*

Inicialización aleatoria de W^N y b^N
Hacer Ite = 1 hastaepocas
Hacer j=1 hasta m

1. Propagar hacia adelante (la entrada hacia la salida)

$$a^N = f^N(W^N a^{N-1} + b^N) \text{ Para toda N} \quad (1)$$

2. Propagar hacia atrás

$$e_j = t_j - a_j^n \quad (2)$$

$$s^n = -2\dot{F}^n(r^n)e_j \quad (3)$$

$$s^{N-1} = \dot{F}^{N-1}(r^{N-1})(W^N)^T s^N \text{ Para toda N } \varepsilon \text{ [n…,3]} \quad (4)$$

3. Actualizar para toda N

$$W^N = W^N - \alpha s^N (a^{N-1})^T \quad (5)$$

$$b^N = b^N - \alpha s^N \quad (6)$$

Fin
Fin

Donde:

W	Vector de pesos
b	Polarización
e	Error
r	Salida antes de la función de activación
t	Salida esperada
s	Sensibilidad de la neurona
α	Tasa de aprendizaje (para el presente trabajo es de .01)
N	Número de capas
m	Total de patrones de entrada
a	Salida obtenida
f	Función de activación

Se empleó la función de activación sigmoide logística para la 1ª y 2ª capa, y la función lineal en la capa de salida.

$$f(r) = \frac{1}{(1+e^{-r})} \quad (7)$$

Para realizar el proceso de aprendizaje de la RNA se organizaron los datos mediante una matriz integrada por 10 columnas (variables meteorológicas) y 53,585 filas (registros diarios), extraídos de la Base de Datos (BD) *tutiempo.net*., provenientes de estaciones meteorológicas ubicadas en diferentes regiones del mundo, de enero de 1990 mayo de 2017.

Para alcanzar eficiencia en el aprendizaje, los datos fueron normalizados a través de la ecuación siguiente

$$Valor\_Normalizado_n = Valor_n / Valor\_Maximo \quad (8)$$

El proceso concluyó al obtener resultados favorables superiores al 80% de precisión, expresados en la figura6.

b) Módulo de análisis de permanencia

Con base en el diagnóstico heurístico emitido por la RNA,el módulo de análisis de permanencia del clima, efectúa conteo de número de días consecutivos en los que tales condiciones están presentes, de igual forma, este módulo permite la interacción con el agricultor, quien podrá capturar los datos climáticos actuales o futuros, con el propósito de conocer de manera oportuna la posibilidad de daño sobre el cultivo. Lo anterior se realiza con base en la expresión siguiente.

$$Si\ (td_i >= 2)\ entonces\ (df_i = 1)$$

Donde:

td	días consecutivos con clima adverso
df	daño fenológico
i	factor climático (i = 1..6)

III. Resultados

A partir de la BD *tutiempo.net*, se extrajo un total de 68,685 registros meteorológicos diarios, donde el 79%fue empleado para el aprendizaje de la RNA y 21% para validarla, todos ellos provenientes de diversas regiones del mundo.

Al finalizar el entrenamiento la RNA, se alcanzó una eficiencia de aprendizaje superior al 90%, luego de suvalidación mediante patrones diferentes a los

© 2018 Global Journals

empleados para el aprendizaje, la red obtuvo alta precisiónen sus diagnósticossuperior al 80%.La figura 6 concentra los resultados obtenidos.

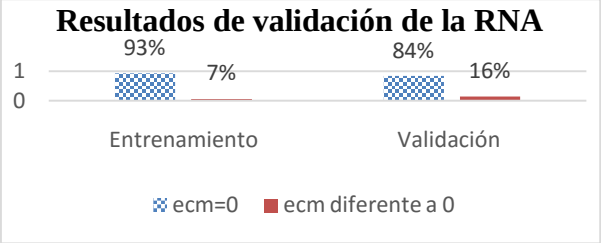


Figura 6: Resultados de validación de la RNA

Posteriormente la red realizó evaluación de cultivos de trigo ubicados en zonas de la República Mexicana, a través de 200 registros de datos climáticos diarios, el diagnóstico de daño emitido se empleó como entrada al módulo de análisis de permanencia de los factores climáticos, con el propósito de identificar la situación del cultivo respecto a posibles daños en alguna de sus etapas fenológicas, los resultados obtenidos fueron correctos en la totalidad de los casos, es decir, la salida obtenida coincidió con la salida esperada.

Para el desarrollo de la RNA se empleó el software científico Matlab versión 2017a.

IV. Conclusiones

El CC constituye un fenómeno no controlado que ocasiona graves daños sobre el desarrollo de los cultivos de trigo, esto a consecuencia de la relación inversa que mantiene con su rendimiento y calidad (Zhao et al., 2017). La mitigación y la adaptación sustentables constituyen un reto importante para la agricultura en todo el mundo, a mediano y largo plazo, se vislumbra un panorama catastrófico para la seguridad alimentaria mundial en caso de no construir estrategias de mitigación y adaptación eficaces.

En apoyo a las estrategias de adaptación sustentables, concentradas en el cómo cultivar el trigo, la estrategia propuesta ofrece información que expresa cuándo reforzar su manejo en correspondencia con la variabilidad climática, luego de su validación y pruebas, se concluye que la RNA expuesta es adecuada para el diagnóstico de daño fenológico por etapa de desarrollo del trigo, permitiendo el monitoreo permanente y por tanto la identificación oportuna de daños posibles, ofrece al agricultor una herramienta que complementa el manejo de cultivo tradicional con el uso de modelos inteligentes, alternativa que representa una estrategia competitiva, apoyada en una estrategia tecnológica de alta precisión, como elemento fortalecedor dela planeación estratégica de los cultivos, el mejoramiento de la producción, la reducción de pérdidas y la seguridad alimentaria.

References Références Referencias

1. Arnell, N. W. (2016). The global-scale impacts of climate change: the QUEST-GSI project. Climatic Change, 134(3), 343-352.
2. Asseng, S., Ewert, F., Martre, P., Rötter, R. P., Lobell, D. B., Cammarano, D. & Reynolds, M. P. (2015). Rising temperatures reduce global wheat production. *Nature Climate Change*, *5*(2), 143-147.
3. Barrero, O., Rojas, D., González, C., & Perdomo, S. (2016). Weed detection in rice fields using aerial images and neural networks. In *Signal Processing, Images and Artificial Vision (STSIVA), 2016 XXI Symposiumon* (pp. 1-4). IEEE.
4. Basche, A. D., Archontoulis, S. V., Kaspar, T. C., Jaynes, D. B., Parkin, T. B., & Miguez, F. E. (2016). Simulating long-term impacts of cover crops and climate change on crop production and environmental outcomes in the Midwestern United States. *Agriculture, Ecosystems & Environment*, *218*, 95-106.
5. Boutraa, T., Akhkha, A., & Al-Shoaibi, A. K. (2015). Evaluation of growth and gas exchangerates of two local saudiwheatcultivarsgrownunderheat stress conditions. Pak. J. Bot, 47(1), 27-34.
6. Chen, Y., Zhang, Z., Tao, F., Palosuo, T., &Rötter, R. P. (2017). Impacts of heat stress onleafareaindex and growthduration of winterwheat in the North China Plain. Field Crops Research.
7. Crimp, S. J., Zheng, B., Khimashia, N., Gobbett, D. L., Chapman, S., Howden, M., & Nicholls, N. (2016). Recent changes in southern Australian frost occurrence: implications for wheat production risk. Crop and Pasture Science, 67(8), 801-811
8. FAO (2002). Agricultura mundial: hacia los años 2015/2030. Informe resumido. http://www.fao.org/docrep/004/y3557s/y3557s08.htm#I
9. Frederiks, T. M., Christopher, J. T., Sutherland, M. W., & Borrell, A. K. (2015). Post-head-emergencefrost in wheat and barley: defining the problem, assessing the damage, and identifying resistance. Journal of experimental botany, 66(12), 3487-3498.
10. Gallo, A. (2015). Assessment of the climate change impact and adaptation strategies on Italian cereal production using high resolution climate data.
11. García, M., Ulloa, H., Ramírez, H., Fuentes, M., Arias, S., & Espinoza, M. (2014). Comportamiento de los vientos dominantes y su influencia en la contaminación atmosférica en la zona metropolitana de Guadalajara, Jalisco, México. Revista Iberoamericana de Ciencias, 1, 97-116.
12. Gaydon, D. S., Wang, E., Poulton, P. L., Ahmad, B., Ahmed, F., Akhter, S., & Choudhury, B. U. (2017).

© 2018 Global Journals

Evaluation of the APSIM model in croppingsystems of Asia. *Field Crops Research*, *204*, 52-75.
13. Ihsan, M. Z., El-Nakhlawy, F. S., Ismail, S. M., & Fahad, S. (2016). Wheat phenological development and growth studies as affected by drought and late season high temperature stress under arid environment. Frontiers in plant science, 7.
14. Iizumi, T., & Ramankutty, N. (2016). Changes in yield variability of major crops for 1981–2010 explained by climate change. Environmental Research Letters, 11(3), 034003.
15. Ji, H., Xiao, L., Xia, Y., Song, H., Liu, B., Tang, L., & Liu, L. (2017). Effects of jointing and booting low temperatura stresses on grain yield and yield components in wheat. Agricultural and Forest Meteorology, 243, 33-42.
16. Jones, A. W., & Phillips, A. (2016). Historic Food Production Shocks: Quantifying the Extremes. Sustainability, 8(5), 427.
17. Lv, H., Lei, T., Huang, X. L., & Zhang, Y. K. (2015). Application of anImproved Grey Neural Network in Grain Yield Prediction.
18. Mansourian, S., Darbandi, E. I., Mohassel, M. H. R., Rastgoo, M., & Kanouni, H. (2017). Comparison of artificial neural networks and logistic regression as potential methods for predicting weed populations on dryland chickpea and Winter wheat fields of Kurdistan province, Iran. *Crop Protection*, *93*, 43-51.
19. Massawe, F., Mayes, S., & Cheng, A. (2016). Crop diversity: an unexploited treasure trove for food security. Trends in plantscience, 21(5), 365-368.
20. OECD/FAO (2017), Perspectivas Agrícolas 2017-2026. OCDE-FAO. Disponible en http://www.agri-outlook.org/OECD-FAO_Outlook_flyer_ES_2017.pdf
21. Pimentel, A. J. B., Rocha, J. R. D. A. S., Souza, M. A. D., Ribeiro, G., Silva, C. R., & Oliveira, I. C. M. (2015). Characterization of heat tolerance in wheat cultivars and effects on production components. Revista Ceres, 62(2), 191-198.
22. Rawson, H. M. Macpherson, G., (2001). Trigo regado: Manejo del cultivo. Food & Agriculture Org. http://www.fao.org/docrep/006/x8234s/x8234s00.htm#Contents
23. Reeves, T. G., Thomas, G., & Ramsay, G. (2016). Ahorrar para crecer en la práctica: maíz, arroz, trigo. Guía para la producción sostenible de cereales.
24. Reynolds, M. P., Quilligan, E., Aggarwal, P. K., Bansal, K. C., Cavalieri, A. J., Chapman, S. C. & Jagadish, K. S. (2016). An integrated approach to maintaining cereal productivity under climate change. Global Food Security, 8, 9-18.
25. Sanad, M. N., Campbell, K. G., & Gill, K. S. (2016). Developmental program impacts phenological plasticity of spring wheat under drought. Botanical Studies, 57(1), 35.
26. Sapkota, T. B., Jat, M. L., Aryal, J. P., Jat, R. K., & Khatri-Chhetri, A. (2015). Climate change adaptation, greenhouse gas mitigation and economic profitability of conservation agriculture: Some examples from cereal systems of Indo-Gangetic Plains. *Journal of Integrative Agriculture*, *14*(8), 1524-1533.
27. Serrano, M. M. (2015). Cambio Climático y la Gran Transformación del Siglo XXI: Hacia un Futuro Sostenible. Derecho & Sociedad, (35), 146-151.
28. Singh MK, Singh BR (2015) Observation and temperatura changes: warming of the climate system and future global warming in 21st century. J PhysSci. doi:10.18090/samriddhi.v5i2.1531
29. Tesfaye, K., Gbegbelegbe, S., Cairns, J. E., Shiferaw, B., Prasanna, B. M., Sonder, K. & Robertson, R. (2015). Maize systems under climate change in sub-Saharan Africa: Potential impacts on production and food security. International Journal of Climate Change Strategies and Management, 7(3), 247-271
30. Torres, I. (2017). La crisis alimentaria Mundial: causas y perspectivas para su entendimiento. WorldFood Crisis: Causes and Prospects for their Understanding. Razón y Palabra, 20(3_94), 602-621.
31. Tripathi, R. C., Kalyani, V. K., Ram, L. C., Jha, S. K. (2015). Prediction of Wheat Yield from Pond Ash Amended Field by Artificial Neural Networks. Journal of Hazardous, Toxic, and Radioactive Waste 19 4, 04015001.
32. United Nations Conferenceon Trade and Development (UNCTAD). (2015). Commodities and Development Report 2015. Smallholder Farmers and Sustainable Commodity Development.
33. Yegnanarayana, B. (2009). Artificial neural networks. PHI Learning Pvt. Ltd.
34. Zhao, C., Liu, B., Piao, S., Wang, X., Lobell, D. B., Huang, Y., & Durand, J. L. (2017). Temperature increase reduces global yields of major crops in four independent estimates. Proceedings of the National Academy of Sciences, 201701762.
35. Zheng, Z., Cai, H., Yu, L., & Hoogenboom, G. (2017). Application of the CSM–CERES–Wheat Model for Yield Prediction and Planting Date Evaluation at Guanzhong Plain in Northwest China. Agronomy Journal, 109(1), 204-217.

© 2018 Global Journals

This page is intentionally left blank

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Gender Participation in Rice Processing Value Chain in kebbi and Sokoto States, Nigeria

By Adam, A. G., Bidoli, T. D., Ammani, A. A. & Oduehie, T. C
Ahmadu Bello University

Abstract- This study examined the men and women participation in rice processing activities in Kebbi and Sokoto States, Nigeria. The specific objectives were to among others: describe the socio-economic characteristics of the rice processors'; ascertain awareness of rice processing technologies among men and women processors; and identify the constraints affecting men and women in rice processing. Data were collected from one hundred and fifty two (152) beneficiaries of the Agricultural Transformation Agenda Support Pragram -1 (ATASP-1) in the Staple Crop Processing Zones of Kebbi-Sokoto, covering (8) LGAs in the two states, purposively selected. The data were analyzed using descriptive statistics. The result of the socio-economic characteristics revealed that the majority (55.3%) had no formal western education, most(57.8%) of the beneficiaries were males, and(42.2%) were females. Similarly, majority(48.1%) were within the age bracket of between 31-40 years of ageand have been in rice processing for between 10 –14years (41.5%).

Keywords: *gender, participation, rice processing.*

GJSFR-D Classification: *FOR Code: 820402, 070399*

Strictly as per the compliance and regulations of:

© 2018. Adam, A. G., Bidoli, T. D., Ammani, A. A. & Oduehie, T. C. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Gender Participation in Rice Processing Value Chain in kebbi and Sokoto States, Nigeria

Adam, A. G. [α], Bidoli, T. D. [σ], Ammani, A. A. [ρ] & Oduehie, T. C [ω]

Abstract- This study examined the men and women participation in rice processing activities in Kebbi and Sokoto States, Nigeria. The specific objectives were to among others: describe the socio-economic characteristics of the rice processors'; ascertain awareness of rice processing technologies among men and women processors; and identify the constraints affecting men and women in rice processing. Data were collected from one hundred and fifty two (152) beneficiaries of the Agricultural Transformation Agenda Support Pragram -1 (ATASP-1) in the Staple Crop Processing Zones of Kebbi-Sokoto, covering (8) LGAs in the two states, purposively selected. The data were analyzed using descriptive statistics. The result of the socio-economic characteristics revealed that the majority (55.3%) had no formal western education, most(57.8%) of the beneficiaries were males, and(42.2%) were females. Similarly, majority(48.1%) were within the age bracket of between 31-40 years of ageand have been in rice processing for between 10 –14years (41.5%). Awareness and ranking of rice processing technologies indicates, rice de-stoned machines, false bottom parboilers, and rice husking machine and polishers. Major constraints were: inadequate funds(48.7%),lack of processing skill centers (38.6%), and inadequate capacity building on processing (32.5%).ATASP-1 should initiate and sustain facilitation and linkages to credit sources so that women and youths can access start–up capital, provision of skill acquisition centers to increase women knowledge in rice value addition and fortification were recommended among others.

Keywords: gender, participation, rice processing.

I. Introduction

Gender plays a significant role in the agricultural sector where both men and women are involved in the agricultural value chain activities that complement each other. The Federal Ministry of Agriculture and Rural Development (FMARD) reported that women accounted for 75% of the farming population in Nigeria (FMARD, 2013). They are largely involved in the production, processing and trading of such food crops such as sorghum, maize, rice, cassava, cowpea, melon, pepper, vegetables, yam and palm oil. Men carry out the tedious tasks such as land clearing and felling of trees, gathering and burning of bush, and making ridges, while the women engage in planting. In addition, women participate in weeding, harvesting, and off-farm processing, and selling of farm produce. Generally, women are rarely associated with agricultural export crops such as cocoa, rubber, cotton. A survey on gender involvement in crop production by National Bureau of Statistics (2014) showed that male involvement in crop production declined, while female involvement was on the increase. However, women often carry out farming and processing tasks using rudimentary technologies. National Bureau of Statistics (NBS) (2014) further reported that women control buying and selling of agricultural processed products such as, cassava and sorghum flour, Gari, and rice. Ademiluaet.al, (2017) noted that the structural role of men and women in agricultural cycle reveal that women are more active specifically in processing and marketing of agricultural products in Nigeria. Accordingly, in the North West zone of Nigeria(47%)of women participation in the business of agricultural product processing and handling as against (22.5%) for men (NBS, 2014).

Despite their enormous contribution, women participation in agricultural production activities is still a challenge (Damisa, and Yohanna 2007). For instance, both men and women have disparityin access to agricultural resources notwithstanding the equal roles they play in agricultural activities.

An analysis of Cassava Value Chain in Nigeria from a Pro-poor and Gender Perspective of Farming Households in Southwest, Nigeria, showed (36.7%)men as compared to (79.3%) of women involvement in the cassava value chain processes (Apata, 2013). Women were also involved in the sales of packaging materials used for most crops and processed foods such as garri, maize and yam flakes (Rahman, 2008). It was argued by Ogunlela and Mukhtar (2009) that if incomes of women are increased, they may have more access to resources and invest in their children's education, health care and nutrition. Menmostly play the part of the middle men as there were hardly "middle women" across the value chain. Also, women were less involved in wholesale but were more active on the retailed side and very visible in open air markets (Okoh, 2009).Recent research findings indicated that women participation in aquaculture in Nigeria is also increasing daily and this has contributed to household food security. Processing has been the most prominent activity of women in fisheries of Lake Kainji and constitutes about 60% of the women (Nwabeze *et. al*, 2013).

Rice*(Oryza sativa)*is the sixth major crop cultivated after sorghum millet, cowpea, cassava and yam and most important staple food for most Nigerian

Author α σ ρ ω: National Agricultural Extension and Research Liaison Services/ Ahmadu Bello University (NAERLS/ABU), Zaria.
e-mail: goniadamali@yahoo.com

© 2018 Global Journals

(Nwalieji, *et. al.,* 2014; National Cereal Research Institute (NCRI), 2004). It is used in the preparation of several local dishes that are eaten in virtually every home, especially during festivals and ceremonies (Julius & Chukwuma, 2014). Rice played a major role in the economy of Nigeria, however, its processing related activities is faced with a lot of challenges in respect to quality and standards which has led to low prices of the commodity in the Country. Agricultural produce processing comprises of all the activities relating to the commodities, the handling, value addition, development of product to additives and fortification. Nwalieji *et al*.(2014) opined that production and processing of rice is always complex and involved distinct stages in successive order as production through harvesting; movement from the farm to processing center; parboiling, drying, milling, de-stoning, polishing and winnowing, moving the milled rice from rural processing center to storage or marketing.

There is a general agreement that gender disparities persists in ownership and access to useful resources such as education, extension and health which have contributed to higher poverty and lower employment opportunities among women. Specifically, gender matters in all aspect of value chain development which ranges from production, processing, handling and marketing. There has been established gender considerations in agricultural value chain development. Hence, there is need for vibrant understanding of the roles of men and women and their level of participation in rice processing value chain development activities among the beneficiaries of ATASP-1in the zone. It is against this background that this study was design to assessed gender participation in rice processing among the beneficiaries of the project in Kebbi-Sokoto zone in the North West, Nigeria; specifically the study sought to:

1. Describe the socio-economic characteristics of the rice processors';
2. Determine the roles of men and women along the rice processing value chain;
3. As certain awareness of rice processing technologies among men and women processors; and
4. Identify the constraints affecting men and women in rice processing.

II. Methodology

The study was conducted in the Staple Crop Processing Zones of Kebbi-Sokoto under the Agricultural Transformation Agenda Support Pragram -1 (ATASP-1).The zone comprises of 8Local Government Areas in the two States. The LGAs are:Kebbi State (Argungu, Bagudu, BirninKebbi, Dandi, Ngaski, Shanga and Suru) and (Kware) in Sokoto State. The inhabitants are predominantly farmers and small to medium scale commodity processors and marketers'. A multi stage sampling technique was employed to select a total of one hundred and fifty two (152) respondents for the study. The first stage involved the purposive sampled of two LGAs namely Kware and Birnin Kebbi were selected from Sokoto and Kebbi states respectively out of the eight LGAs of the zones. In the second stage, with the assistance of extension staff in the selected (LGAs), four communities were also selected, two from each LGAs. The condition that guided the selection of communities was the availability of the project activities. The third stage was a random sampling often (10%) sample size from the population of the beneficiaries which was one thousand five hundred and twenty five (1,525), which formed the sampling frame.Therefore, total sample for the study were two LGAs, four communities and 152 respondents' as shown in Table 1.Data were collected from the respondents' using structured interview schedule and were analysed using descriptive statistics such as frequencies and percentages.

Table 1: States, LGAs, Communities and respondents for the Study

State	LGAs	Community	Population	10% sample Size
Kebbi	BirninKebbi	BirninKebbi	540	54
		Gwadangwaji	281	28
Sokoto	Kware	GidanTambari	340	34
		GarinKware	364	36
Total			**1,525**	**152**

III. Results and Discussion

a) Socio-economic characteristics of rice processor'

Table 1 showed the socio-economic characteristics of rice processors in the study area. Results revealed that majority (48.1%) of the respondents were between the age bracket of 31 – 40years, married (63.2%), had no formal education (55.3%), have been in rice processing between 10 – 14years (41.5%) and have a household size of 6 – 10 persons (48.7%). This implies that the rice processors were within their active and reproductive age, saddled with the responsibility of looking after their family, having a fairly large household size of 8 persons, have been processing rice for over 14years and had fairly low level of literacy.

© 2018 Global Journals

Table 2: Socio-economic characteristics of the respondents (n=152)

Variable	Frequency	Percentage
Sex		
Male	88	57.8
Female	64	42.2
Age (years)		
Less than or equal to 20	13	8.5
21-30	29	19.1
31-40	73	48.1
41-50	22	14.5
Above 50	15	9.8
Years of Experience in rice Processing		
1-4	22	14.5
5-9	31	20.4
10-14	63	41.5
15 and above	26	17.1
Marital Status		
Married	96	63.2
Single	31	20.4
Widowed	18	11.8
Divorced	7	4.6
Household Size		
1-5	29	19.2
6-10	74	48.7
11-15	28	18.5
16 and above	21	13,6
Educational Level		
No formal education	84	55.3
Primary education	35	23.1
Secondary education	25	16.4
Tertiary education	8	5.2

Source: field Survey, 2017

b) Types of operations in rice processing activities

Figure 1 showed the type of operations carried out by the processors according to gender in rice processing and handling activities. Operations like parboiling, (69.6%), drying, (54.8%), winnowing (57.9%), Fortification/additives (27.9%) and Product development and diversification (26.4%) were mostly performed by women. Similarly, milling and polishing (27.8%), sorting and grading (21.1%), packaging and bagging (11.3%), handling and transportations (28.9%) operations are mostly executed by men. This implies that both gender participated in the rice processing value chain activities in the ATASP-1 project in the zone, however women appears to be more involved in the core value addition activities than men.

© 2018 Global Journals

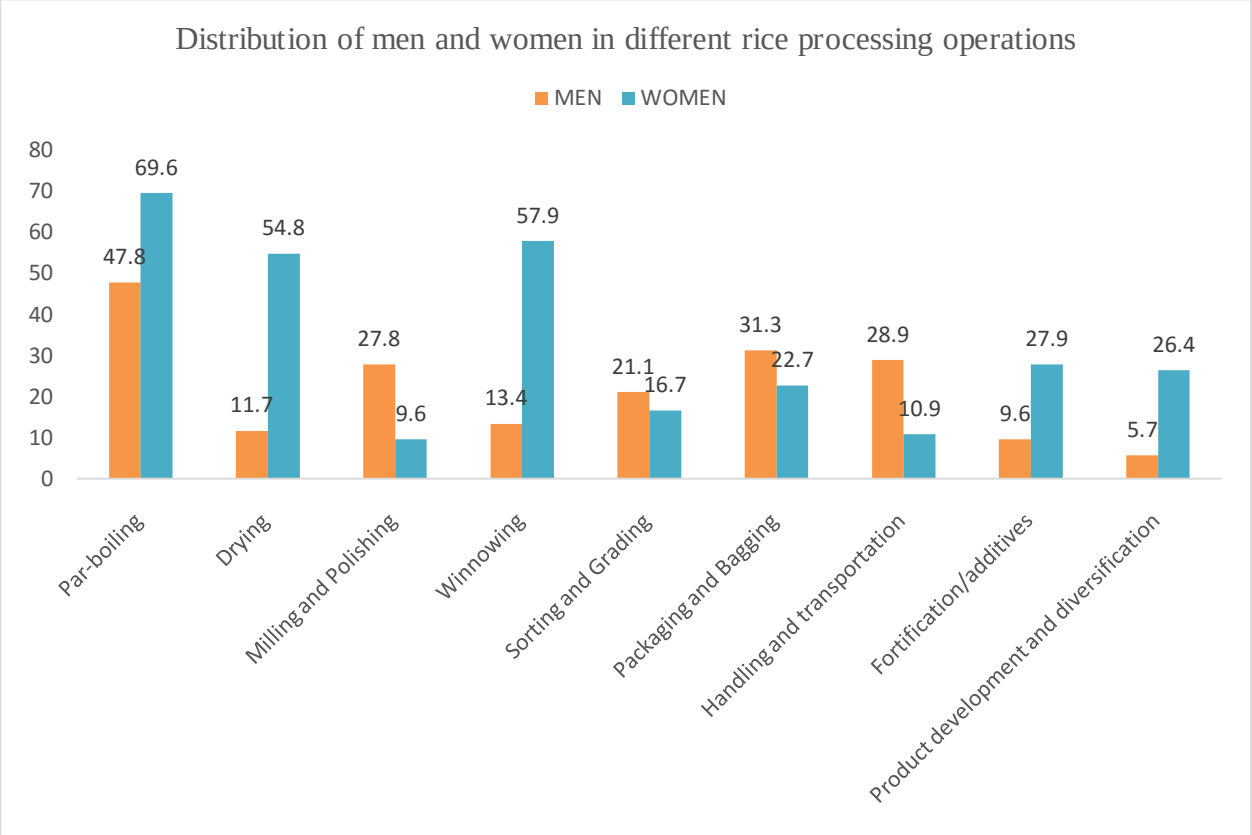


Figure 1: Showing percentage of men and women in different rice processing operations multiple responses

c) *Gender Awareness' of Improved Rice Processing Technologies*

Table 3 showed gender awareness of improved rice processing technologies among the ATASP-1 beneficiaries. Most women ratedrice husking machines, rice de-stoned machines and false bottom parboilers' as the most essential technologies that can benefit them in their rice processing value chain activities. While the men ranked rice de-stoned machines, False bottom parboilers and rice milling machines were the most valuable technologies which could support their activities as presented in Table 3. The results implies that most of the rice processors were aware of improved technologies that might benefits both men and women in their processing activities, howevermajority appears to lack access to these equipment. This could be attributed to the fact that most of the people in the study area are small-medium scale processors and marketers who lack access to reproductive resources.

Table 3: Distribution of Respondents Awareness of Rice Processing Technologies (n=152)*

Rice Processing Technologies	Awareness and ranking of Processing Technologies			
	Men(n=88)		Women(n=64)	
	Frequency	Rank	Frequency	Rank
Rice milling/grinding machines	27	3	24	4
Simple threshers for rice	16	9	9	14
Rice de-stoned machines	32	1	27	2
Rice par-boilers equipment	25	4	23	5
Rice polishers	17	8	20	6
Rice husking machines	19	7	29	1
Paddy separator's and polishers	11	13	14	12
False bottom parboilers	29	2	26	3
Simple grinding machine	15	10	16	10
Simple dryer	21	5	19	7
Grain sorting machine	20	6	17	9
Customized package/bag	8	14	18	8
Gem parboilers	12	12	12	13
Flash drier	14	11	15	11

**Multiple responses*
Source: field Survey, 2017

© 2018 Global Journals

d) Constraints Affecting Rice Processing Activities

The important constraints that affects rice processing and its value chain activities in the study area are presented in Table 4.

The results in Table 4 revealed inadequate funds to procure improved processing machineries (48.7%), lack of processing skill centres (38.6%) and inadequate capacity building activities on processing and value addition on rice (32.5%)and lack of technical knowledge on rice value addition/fortification (23.9%) were the major factors affecting rice processing activities which were ranked next to each other respectively. This implies that majority of the processors need alternative sources of funds to purchase those desirable improved processing technologies and equipment. This is because majority of women in the rural areassourced capitals for stating agro-businesses through personal savings (Adam and Bidoli, 2017).

Table 4: Constraints affecting rice processing activities

Variables	Frequency*	Percentage	Rank
Inadequate female extension workers	18	9.2	6
Lack of technical knowledge on rice value addition/fortification	47	23.9	4
Lack of access to simple labour saving devices and equipment	20	10.2	5
Inadequate funds/capital	42	48.7	1
Lack of processing skill centers	25	38.6	2
Inadequate capacity building activities on processing and value addition on rice	29	32.5	3
Limited mobility	16	8.1	7

** Multiple responses*

Source: field Survey, 2017

IV. Conclusion and Recommendation

The study showed that the beneficiaries' were mostly men, majority were between the productive average age of 35years, and most had fairly low level of education. There is high level of experience in rice processing activities among the beneficiaries. This is critical which could influence their processing activities and enhance the value chain addition to their rice.Majority of the beneficiaries were aware of improved rice processing technologies that will benefit them, however, most of them lack access to these desirable equipment. Factors such as inadequacy of funds to acquire improved processing machineries, lack of processing skill centres and inadequate capacity building activities on processing and value addition were the serious constraints affecting rice processing activities. Therefore, it was recommended that:

1. ATASP-1 should initiate and sustain facilitation and linkages to credit sources with favorable interest rates so that vulnerable women and youths can access start–up capital for increased productivity.
2. ATASP-1 should provide female skill acquisition centers in each of the ATASP-1 LGAs in order to increase women knowledge in rice value addition and fortification for greater participation in project activities.
3. More rice processors should be encouraged to participate through expansion of the project to cover more L.G.As of Sokoto State.

References Références Referencias

1. Adam, A. G. and Bidoli, T. D. (2017). Assessment of Gender Roles among Agro- Inputs Entrepreneurs in North West, Nigeria. (Jibril et.al edited). Proceedings of the 31st Annual National Conference of the Farm Management Association of Nigeria (FAMAN) held at Abubakar Tafawa Balewa University, Bauchi, Nigeria, 9th-12thOctober. 274-280.
2. Anaglo J. N., Boateng S. D. and Boateng C. A. (2014). Gender Access to agricultural Resources by Smallholder farmers in the Upper West Region of Ghana. Journal of Education and Practice ISSN 2222 – 1735 – 5 (5):13-19.
3. Apata T.G., (2013). Analysis of Cassava Value Chain in Nigeria, from a Pro-poor and Gender Perspective of Farming Households in Southwest, Nigeria. Merit Research Journal of Agricultural Science and Soil Sciences (ISSN: 2350-2274) 2(11):147-153.
4. Dambatta M. A., Sogbesan O. A., Fagge A.U., Suleiman I. D. andShuaibu A.U. (2016). Role of Women in Fisheries and Aquaculture in Kano State, Nigeria: Journal of Biology, Agriculture and Healthcare ISSN 2224-3208 (Paper) ISSN 2225-093X (Online) 6(14): 56-78
5. Damisa, M. A. and Yohanna M. (2007). Role of rural Women in farm management decision making process: Ordered Probit Analysis Trends in Applied Science Research, 2(3): 241-145.
6. FMARD (2013). Federal Ministry of Agriculture and Rural Development, Score Card: FMA&RD Mid-Term Report January 1, 2013 – December 31, 2013.
7. Mtsor, Y.G. and Idisi, P.D. (2014). Gender Inequality and Women Participation in Agricultural Development in Nigeria. Merit Research Journal of Education and Review. 2(11):269-301.
8. National Bureau of Statistics (2014). Gender Dimensions to Livelihoods in Nigeria: General Household Survey Panel (GHS-Panel). Available at www.nigerianstat.gov.ng
9. Nwabeze, G.O., Ifejika, P.I., Tafida A.A., Ayanda, J.O., Erie, A.P. and Belonwu, N.E. (2013). Gender

© 2018 Global Journals

and Fisheries of Lake Kainji, Nigeria: A Review. Journal of Fisheries and Aquatic Science, 8: 9-13.
10. Nwalieji, H. U., Madukwe, M.C, Agwu, A.E and Umerah, M. I (2014). Adoption of Rice Technologies Introduced by the United States Agency for International Development in Anambra and Ebonyi States, Nigeria: Journal of Agricultural Extension. 18(1): 158-169.
11. Ogunlela Y.I. and Mukhtar A. A. (2009). Gender Issues in Agriculture and Rural Development in Nigeria: The role of women. Humanity and Social Sciences Journal 4(1): 19-30, 2009 ISSN 1818-4960.
12. Okoh, R.N. (2009). Gender Budgeting for Agriculture and Rural development in Nigeria. Paper Presented at the IAFFE Conference held at Boston, USA. 26-28 June, 2009.
13. Rahman, S.A. (2008).Women's involvement in Agriculture in Northern and Southern Kaduna State. Journal of Gender Studies, 17:17-26.
14. World Bank (2013). Women, Business and the Law. Creating Economic Opportunities for Women (http://wbl.worldbank.org/data/exploreeconomies/nigeria/2013 accessed 10 October 2016).

© 2018 Global Journals

Global Journal of Science Frontier Research: D
Agriculture and Veterinary
Volume 18 Issue 2 Version 1.0 Year 2018
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Potassium Release Kinetics from Dioctahedral and Trioctahedral Minerals under Alkaline Conditions

By Umair Riaz, Irshad Bibi, Nabeel Khan Niazi, Ghulam Murtaza & Humera Aziz

University of Agriculture Faisalabad

Abstract- The agricultural significance of Potassium (K) has been comprehensively documented owing to its role in plant development and growth. The reserves of K in soil are not available to plant roots for uptake as 98% of the total soil K is mineral bound. The K bearing 2:1 type clay minerals can serve as an enormous and renewable pool of K supply in soil. The K releasing capacity of these minerals is governed by different agents like ionic strength, temperature and pH. Therefore, the release K from dioctahedral (Muscovite) and trioctahedral (Biotite) pure minerals were investigated at 25±1°C in batch reactors over the pH range of 8 to 12. The experiments performed until the steady state was achieved. At the start of each experiment, the high output solutions concentrations of Fe, Si, K and Al were recorded, after that a gradual reduction was observed leading to the establishment of steady state conditions. The release of Kwas more from the dissolution of biotite thanmuscovite dissolution.

Keywords: *mica, potassium, biotite, muscovite, alkaline pH, dissolution.*

GJSFR-D Classification: *FOR Code: 050399*

Strictly as per the compliance and regulations of:

© 2018. Umair Riaz, Irshad Bibi, Nabeel Khan Niazi, Ghulam Murtaza & Humera Aziz. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License http://creativecommons.org/licenses/by-nc/3.0/), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Potassium Release Kinetics from Dioctahedral and Trioctahedral Minerals under Alkaline Conditions

Umair Riaz [α], Irshad Bibi [σ], Nabeel Khan Niazi [ρ], Ghulam Murtaza [ω] & Humera Aziz [¥]

Abstract- The agricultural significance of Potassium (K) has been comprehensively documented owing to its role in plant development and growth. The reserves of K in soil are not available to plant roots for uptake as 98% of the total soil K is mineral bound. The K bearing 2:1 type clay minerals can serve as an enormous and renewable pool of K supply in soil. The K releasing capacity of these minerals is governed by different agents like ionic strength, temperature and pH. Therefore, the release K from dioctahedral (Muscovite) and trioctahedral (Biotite) pure minerals were investigated at 25±1°C in batch reactors over the pH range of 8 to 12. The experiments performed until the steady state was achieved. At the start of each experiment, the high output solutions concentrations of Fe, Si, K and Al were recorded, after that a gradual reduction was observed leading to the establishment of steady state conditions. The release of Kwas more from the dissolution of biotite thanmuscovite dissolution. The both rates ranged at steady state between -10.13 mol $g^{-1}s^{-1}$ and -8.84 mol $g^{-1}s^{-1}$ at pH 8-12, respectively. The dissolution rates of muscovite (R_{Si}) ranged between -9.64 mol $g^{-1}s^{-1}$ and -8.44 mol $g^{-1}s^{-1}$ at pH range 8 to 12, respectively. It is concluded that the solution pH has an affect significantly to the K release from biotite and muscovite dissolution. These results suggest that biotite-rich soils may have a relatively rapid leaching of K under alkaline conditions and have less K-fertilizer requirements as compared to muscovite dominant soils.

Keywords: mica, potassium, biotite, muscovite, alkaline pH, dissolution.

I. Introduction

Each nutrient plays distinctive functions in plants. In agricultural sector the significance of K is largely studied and documented due to its vital role in plant growth and development (Oborn *et al.,* 2005). Different agricultural systems reported the deficiency of K(Zorb *et al.,* 2014). Potassium has been declared as a limiting factor in soils Pakistan (30-35 %), China 25-75% and in South Australia (66%) (Akhtar *et al.,* 2003; Jaiswal *et al.,* 2016). On an average in Pakistani Soils K is added through fertilizers less than 1.0 kg K_2O ha^{-1}while K output is about 15.0 kg K_2O ha^{-1}.Pakistani Soils are characterized by uncertain weathering of K containing minerals (Haider *et al.,* 2016). According to the results of a study, the soil series of NWFP (35%), Sindh (8%) and Punjab (28%) had insufficient K levels. Potassium can be released at the rate of about 35-70 kg K $ha^{-1}a^{-1}$from the soils rich in clay minerals.(Simonsson *et al.,* 2007).The Soils forms of K can be categorized into structural, exchangeable and non-exchangeable (Schneider *et al.,* 2016). In soils, K is found in two major forms: exchangeable and non-exchangeable. The non-exchange able K is fairly high in amount ranging from 90-98% of total K in soil and is mainly found as trapped between clay minerals inter layers.

It comprises of K in two interlayer sites of micaceous earth minerals, for instance illite and K from feldspar minerals. It is gathered that replaceable K ions are adsorbed on edges sites of earth minerals, soil natural issue and on trade destinations of smectite minerals (Dotaniya *et al.,* 2016).

The non-exchangeable K is released from illite and mica minerals as a result of the lowering of K level in soil solution and its exchangeable form due to plant uptake(Barre *et al.,* 2007; Carey and Metherell, 2003; Singh and Schulze, 2015).According to literature, 2:1 type clay minerals serve as a major K pool having capacity of supplying K exceeding upto 3t ha^{-1}.The most important K-containing minerals common in soils are illite (32 to 56 g K kg^{-1}), K-feldspars (20 to 30 g K kg^{-1}), the trioctahedral mica: biotite (Mg mica, 36 to 80 g K kg^{-1}) and dioctahedral mica: muscovite (K mica, 60 to 90 g K kg^{-1}(Jalali, 2006). The K found in fixed form can also be replaced by dissolution, by the conversion of mica into 2:1 layer silicates and also by ion exchange.

In any case, a sweep of the literature reveals that these examinations go back to not over 20 years or something like that. Soil K-bearing minerals, in the request of arrival of their K to plants are orthoclase, microcline, muscovite, and biotite. Mineral K is that part of total K that is accessible to plants after releasing and its availability is governed by different factors including degree of weathering, mineral K fraction, and K level in soil solution(Basak and Biswas, 2009; Dotaniya *et al.,* 2016). The dissolution of minerals is the main phenomena affecting different biological, chemical and physical reactions in soil(Lerman and Meybeck, 2012). It specifically controls the nutrients supplying capacity of

Author α σ ρ ω ¥: Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Faisalabad-38040, Pakistan.
e-mail: umair.riaz@uaf.edu.pk
Author σ: MARUM and Department of Geosciences, University of Bremen, Bremen D-28359, Germany.
Author ρ: Southern Cross Geo Science, Southern Cross University, Lismore 2480 NSW, Australia.

© 2018 Global Journals

soil essential for plant development(Wilson, 2004). Numerous studies have evaluated the muscovite and biotite dissolution; however, most of them were carried out in neutral and acid pH conditions(Li *et al.,* 2014; Malmstrom and Banwart, 1997; Xue *et al.,* 2016). The release of K from muscovite and biotite is significantly affected by the K ions movement in soil solution through cation exchange process. The dependence of phyllosilicate minerals dissolution on pH is generally considered to be the attachment ofH^+ and OH^- to Si and Al reaction sites(Brady and Weil, 2008) hence forming activated complexes of phyllosilicate minerals containing negative, positive and neutral charge at alkaline, acid and neutral pH respectively(Crundwell, 2014).

A lot of experiments have been performed on dissolution kinetics of biotite and muscovite in acidic conditions but still there is lacking of information about weathering of both minerals in alkaline environment. Therefore, the main objective of the current investigation was to unravel the effect of varying alkaline pH (8-12) on biotite and muscovite dissolution kinetics at 25 °C and assessment of the release of K from biotite and muscovite.

II. Methodology

a) Collection and preparation of minerals

The fresh biotite and muscovite obtained from Excalibur Mineral Corporation, Charlottesville United States of America. Their chemical composition obtained from the company is given in Table 1. Both micas were in enormous crystal forms having few cm thicknesses. The minerals were cut in ethanol in a food processor using Knife blade for size reduction. Uniform particle sizes was achieved after separation of the <250 μm fractions in ethanol by wet sieving.

b) Experimental setup

The 200 mg each mineral sample reacted with 40 mL input solution with varying pH solutions (pH 8-12) in Teflon vessels placed in a thermostatic water bath (WB/OB 7-45, Memmert) at a temperature of 25±1 °C in controlled temperature room of University of Agriculture, Faisalabad. The ionic strength of all input solution was maintained constant at 0.01*M* by NaCl. The experiment proceeds for a period of time until the steady state has been reached. When the consecutive samples showed <6% difference in Si concentrations it was considered that steady state has been reached (Bibi *et al.,* 2011) and we confirmed the steady state for seven consecutive samples in this experiment.

c) Output solution analyses

From each batch the output solutions were collected after every 24 hand filtered with Whatman filter paper 42. Immediately after collecting, the samples were subjected for pH measurement using a pre-calibrated combined pH electrode (HM-12P pH meter, accuracy ± 0.02 pH units).The Si concentrations were determined colorimetrically (UV visible spectrophotometer) by adopting molybdate blue method(Koroleff, 1976) and Al concentrations were measured colorimetrically by the catechol violet method (Dougan and Wilson, 1974). The Fe and K were determined by flame atomic absorption spectrophotometer (FAAS; Model Thermo S-Series, Thermo Electron Corporation, Cambridge, UK). The use of glassware was avoided at all stages of the experiment to prevent Si contamination.

From each group the output solutions were gathered after each 24 h and separated with Whatman filter paper 42. Promptly in the wake of gathering, the samples were subjected for pH estimation utilizing a pre-aligned joined pH cathode (HM-12P pH meter, precision ± 0.02 pH units). The concentration of Si was detected on spectrophotometer (UV visible) by embracing molybdate blue strategy (Koroleff, 1976) and Al fixations were measured colorimetrically by the catechol violet technique (Dougan and Wilson, 1974). The Fe and K were ditacted by atmic absorption spectrophotometer (Thermo Electron Company, Cambridge, UK).

d) Dissolution rate calculations

The dissolution rate *R* (mol g^{-1} s^{-1}) was calculated from the data obtained when steady state was achieved from the output concentrations of Al, Fe and Si by adopting the following expression (Bibi *et al.,* 2011; Rozalen *et al.,* 2009):

$$R = \frac{dC_{Si} \times M_{sol}}{dt\, V_{Al/si} \times M_{Mineral}}$$

Whereas:

R=dissolution rate(mol g^{-1} s^{-1}), dC_{Si} = concentration of Si in the steady state solution (µM).

dt = time (days). M_{sol} = mass of output solution (g). $M_{mineral}$ = mass of mineral (biotite or muscovite) (g), $V_{Al/Si}$ = stoichiometric ratio.

e) Statistical analysis

The information was subjected to statistical investigation. The descriptive statistics was applied using Microsoft Word Excel program and software OriginPro®(Steel *et al.,* 1997).

III. Results

a) Impact of pH on cations release

Figure 1 a-e shows the comparison between the Si release from biotite and muscovite dissolution with pH range of 8-12.The initial Si release was 158µM and 170 µM at pH 12 while 45µM and 58.06 µM at pH 8 from muscovite and biotite, respectively. It was also observed from the data the Si release more from biotite as compared to muscovite. The highest initial Al release rates was recorded at the highest pH 12 i.e., 52µM and

© 2018 Global Journals

the lowest Al release rate recorded at the lowest pH 8 i.e., 29μM. The release of Al was 43% more at pH 12 as compared to release at pH 8 from biotite.The maximum Fe released from biotite was found in output solution of pH 12 (250% more) at all days samples while minimum in pH 8 samples (Figure 3, a-e).

The comparison of K release from biotite and muscovite shows in Figure 5 a-j. There lease of K from muscovite was at the most elevated pH 12 and the least at pH 8 with the estimations of starting discharge 1772 μM and 1014 μM, individually. Results indicated 42% more arrival of K at pH 12 than the most reduced pH 8. If there should arise an occurrence of biotite (Figure 4 f-j) at pH 8 the K initial discharge rate was 989 μM which is the most minimal from of all K initial discharge rates, at pH 12 it was 1817 μM which was most noteworthy beginning release rate in all pHs and this augmentation was 45% more when contrasted with the least pH 8. For the most part, as the pH expanded from 8 to 12 the underlying K discharge rates likewise expanded in both type of minerals.

b) Impact of Time on the Discharge of Elements

The release rates of Si, Al, Fe and K are plotted against time (days) in Figure 1, 2, 3 and 4, respectively. At the initial days of the experiments, Si was released at faster rate from both biotite and muscovite. The initial fast Si release was followed by a gradual decrease until becoming stable at the steady state (Figure 1). The state of stability (steady state) in release of Si achieved earlier in 25 days where input pH was greater than 10 but at lower pH 8 and 9 the stability achieved after 35 days. In case of Al in muscovite, the release (Figure 2, a-e) followed the same trend like Si; the concentration of Al was highest (255% more) at initial days of experiment but becomes lower after 25 days and achieved the steady state. These figures indicated that the discharge/release rates were changed with respect to time. It was also evident that the release was rapid during first few days and then gradually decreases to the stable form. It also shows that some variation in rates occurs throughout the experiments. In some cases the changes of rate correlate with deliberate or inadvertent changes in tentative situations. Figure 1 a-e shows the comparison between the Si release from biotite and muscovite dissolution with pH range of 8-12. At the initial stages of the experiments, Si was released at faster rate from both biotite and muscovite. The initial fast Si release was followed by a gradual decrease until becoming stable at the steady state (Figure 1).

c) Influence of pH on dissolution of biotite and muscovite

The mass based dissolution rates of biotite and muscovite calculated from Si release at the steady state are shown in Table 2 and Figure 6. Strongest pH dependence of both minerals on dissolution rates was observed. The dissolution rates of both minerals increased with an increase in pH from 8-12. The log normalized dissolution rate of biotite (R_{Si}) calculated from Si release at the steady state and initial mineral mass ranged between -10.13 mol $g^{-1}s^{-1}$ and -8.84 mol $g^{-1}s^{-1}$ at pH 8-12, respectively. The dissolution rates of muscovite (R_{Si}) ranged between -9.64 mol $g^{-1}s^{-1}$ and -8.44 mol $g^{-1}s^{-1}$ at pH range 8 to 12, respectively. Biotite dissolved at a much faster rate compared to muscovite at the whole pH ranges investigated in this study (Figure 6). The fractional reaction orders calculated from the linear regression of the plot of log R_{Si} against pH (Figure 6) for biotite and muscovite are 0.34 and 0.28, respectively.

IV. Discussion

Underbasic, neutral and acidic conditions, the agents responsible for attack on the surface of minerals are hydroxyls, water molecules and protons, respectively. At every pH, the dissolution rate (*R*) is proportionate to order of protons (H^+) activity. Typically the activity of water may be regarded as unity, and the water molecule-promoted dissolution rates will be approximately constant (Bibi *et al.,* 2011).In the present study, during initial days of experiment, Si was released more as compared to later days. This higher release of Si at the initial stages probably because of the production of polymeric species, $H_2SiO_4^{-2}$ and H_3SiO_4.The solubility of most Si containing oxides and mixed oxides increased due to the aggravated OH^- concentration (Rozalen *et al.,* 2009; Bibi *et al.,* 2011, 2012).

Similar decreasing trend of Al concentration followed by Si with time (Figure 1 and 2) due to the OH anions attack on the bridging O bonds of both Al-O-Si and Al_2-O-Si sites existing on the edge surfaces, catalysed by protonated Al-OH groups (Kuwahara, 2006).In all experiments, K release pattern showed similar trend as that of other cations, with higher release rate in start.

It has been demonstrated earlier that as a result of ion exchange reactions between mineral interlayer and solution, clay minerals firstly release interlayer cations. The rates of these reactions are controlled by diffusion. For example, Metz et al. (2005) revelaed that the prompt release of Ca, Na and Mg from smectite causing in a reduction of the interlayer of muscovite, biotite and phlogopite. Though solid-state Fe oxidation can take place in the course of biotite alteration, this reaction does not necessarily cause stoichiometric Fe release to solution. Several studies have indicated that octahedral cations (primarily Al, Mg and Fe) are preferentially released during biotite dissolution (Acker and Bricker, 1992; Kalinowski and Schweda, 2007; Kuwahara, 2006; Newman and Brown, 1966).In this study, the release of K was totally dependent on pH (Figure 4) as more K was released with increasing of

© 2018 Global Journals

pH. Our results are accordance with Malmstrom and Banwart, (1997), they described that at high pH range, and release of interlayer K becomes more important for total dissolution of mica minerals. The desorption of H^+ at basic pH was reported to be responsible cation release from biotite dissolution at basic pH.

The muscovite and biotite rates of dissolution are controlled by a pioneer complex made by the Si, Fe and Al release from the structure of biotite and muscovite(Oelkers *et al.,* 2008). In alkaline conditions, the dissolution rates of muscovite and biotite depend on Si concentration in aqueous solution in addition to Fe and Al concentration. It has also been suggested that at basic pH, octahedral Al-O bond is the slowest to break; therefore the rates are controlled by both the removal of tetrahedral Si and octahedral Al from the mineral structure(Bibi *et al.,* 2011; Rozalen *et al.,* 2009). Among the mica minerals, biotite proved to be more weather able than muscovite because shortened K-O bond presence in muscovite which is resistant to the dissolution. Further the interlayer K is also less tightly bound in biotite than muscovite. Previously, Bickmore *et al.,*(2006)advocated that under alkaline conditions the quartz dissolution seemed to proceed by attacking of hydroxyl ions (OH^-)which initiated by the existence of a silanol group (neutral). In the first mechanism, an OH^- ion outbreaks the oxygen atom of a siloxane group ($>Si_2O$) and is speed up by the existence of a >Si-OH group, this phenomenon evident that the rate of dissolution (*R*)may be proportional to the concentration of OH^-. The first mechanism would tend to dominate at higher pH, since the concentration (or activity) of OH^- would go up with temperature for a given in situ pH but the fraction of deprotonated surface sites would remain constant. Our results are also agreement with the Kuwahara, (2006)who proposed that this mechanism can be applied to montmorillonite dissolution under alkaline conditions, that is, OH^- ions would outbreak the bonding of O bonds of mutually Al-O-Si and Al_2-O-Si sites present on the edge sides, more concentration of OH^-cause more dissolution of montmorillonite.

V. Conclusion

It is concluded that the dissolution of mica minerals (biotite, muscovite) increased with an increase in pH under alkaline range and the trioctahedral mineral (biotite) is easily dissolved than dioctahedral mineral (muscovite). Soils with high pH (>8) have large amount of K than that in low pH soils because dissolution rate of minerals high at such pH values. It is further recommended that K-fertilizer requirements for the soils having trioctahedral mineral (biotite) would be less as compared to soils containing dioctahedral mineral (muscovite).

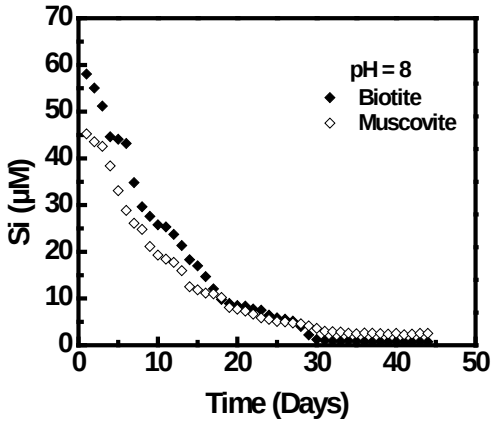
References Références Referencias

1. Acker, J.G. and O.P. Bricker. 1992. The influence of pH on biotite dissolution and alteration kinetics at low temperature. Geochim. Cosmochim. Acta. 56:3073-3092.
2. Akhtar, M., M. Saleem and M. Stauffer. 2003. Potassium in Pakistan agriculture. Pakistan Agriculture Research Council, Islamabad:50.
3. Barre, P., B. Velde, N. Catel and L. Abbadie. 2007. Soil-plant potassium transfer: impact of plant activity on clay minerals as seen from X-ray diffraction. Plant Soil. 292:137-146.
4. Basak, B. and D. Biswas. 2009. Influence of potassium solubilizing microorganism (Bacillus mucilaginosus) and waste mica on potassium uptake dynamics by sudan grass (Sorghum vulgare Pers.) grown under two Alfisols. Plant Soil. 317:235-255.
5. Bibi, I., B. Singh and E. Silvester. 2011. Dissolution of illite in saline–acidic solutions at 25 °C. Geochim. Cosmochim. Acta. 75:3237-3249.
6. Bibi, I., 2012. Mineralogy and acid neutralisation mechanisms in inland acid sulfateenvironments. Ph.D. Thesis. Faculty of Agriculture and Environment, TheUniversity of Sydney, Sydney.
7. Bickmore, B.R., K.L. Nagy, A.K. Gray and A.R. Brinkerhoff. 2006. The effect of $Al(OH)_4^-$ on the dissolution rate of quartz. Geochim. Cosmochim. Acta. 70:290-305.
8. Brady, N. and R. Weil. 2008. An introduction to the nature and properties of soils. Prentice Hall, Upper Saddle River, NJ.
9. Carey, P. and A. Metherell. 2003. Rates of release of non-exchangeable potassium in New Zealand soils measured by a modified sodium tetraphenyl-boron method. New Zeal. J. Agric. Res. 46:185-197.
10. Crundwell, F. 2014. The mechanism of dissolution of minerals in acidic and alkaline solutions: Part II Application of a new theory to silicates, aluminosilicates and quartz. Hydrometallurgy. 149:265-275.
11. Dotaniya, M., V. Meena, B. Basak and R.S. Meena. 2016. Potassium Uptake by Crops as Well as Microorganisms, Potassium Solubilizing Microorganisms for Sustainable Agriculture. Springer.p. 267-280
12. Dougan, W. and A. Wilson. 1974. The absorptiometric determination of aluminium in water. A comparison of some chromogenic reagents and the development of an improved method. Analyst. 99:413-430.
13. Haider, N., S. Khan, A. Ali and L. Ali. 2016. Mineralogical and geochemical study of bentonite deposits of Garhi Chandan area, District Nowshera, Khyber Pakhtunkhwa, Pakistan. Arabian J. Geosci. 9:1-10.

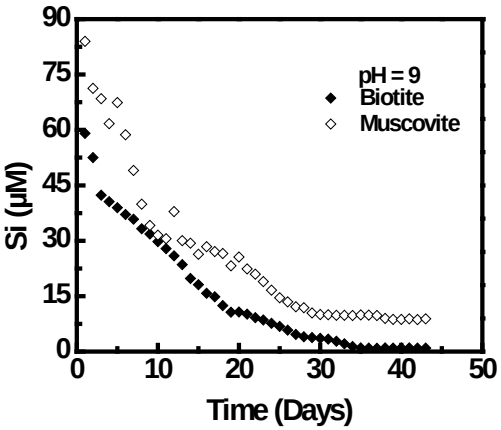
© 2018 Global Journals

14. Hinsinger, P. 2002. Potassium. In: Lal, R. (Ed.), Encyclopedia of Soil Science. Marcel Dekker, Inc., New-York, USA.
15. Jaiswal, D.K., J.P. Verma, S. Prakash, V.S. Meena and R.S. Meena. 2016. Potassium as an Important Plant Nutrient in Sustainable Agriculture: A State of the Art, p. 21-29 Potassium Solubilizing Microorganisms for Sustainable Agriculture. Springer.
16. Jalali, M. 2006. Kinetics of non-exchangeable potassium release and availability in some calcareous soils of western Iran. Geoderma. 135:63-71.
17. Kalinowski, B.E. and P. Schweda. 1996. Kinetics of muscovite, phlogopite, and biotite dissolution and alteration at pH 1–4, room temperature. Geochim. Cosmochim. Acta. 60:367-385.
18. Kalinowski, B.E. and P. Schweda. 2007. Rates and nonstoichiometry of vermiculite dissolution at 22 C. Geoderma 142:197-209.
19. Koroleff, F. 1976. Determination of silicon. In Methods of Seawater Analysis (ed. K. Grasshoff), pp. 149-158. Springer Verlag.
20. Kuwahara, Y. 2006. In-situ AFM study of smectite dissolution under alkaline conditions at room temperature. Am. Mineral. 91:1142-1149.
21. Lerman, A. and M. Meybeck. 2012. Physical and chemical weathering in geochemical cycles Springer Science & Business Media.
22. Li, J., W. Zhang, S. Li, X. Li and J. Lu. 2014. Effects of citrate on the dissolution and transformation of biotite, analyzed by chemical and atomic force microscopy. Appl. Geochem. 51:101-108.
23. Malmstrom, M. and S. Banwart. 1997. Biotite dissolution at 25 C: The pH dependence of dissolution rate and stoichiometry. Geochim. Cosmochim. Acta. 61:2779-2799.
24. Metz, V., K. Amram and J. Ganor. 2005. Stoichiometry of smectite dissolution reaction. Geochim. Cosmochim. Acta. 69:1755-1772.
25. Newman, A. and G. Brown. 1966. Chemical changes during the alteration of micas. Clay Miner. 6:310.
26. Oborn, I., Y. Andrist-Rangel, M. Askekaard, C. Grant, C. Watson and A. Edwards. 2005. Critical aspects of potassium management in agricultural systems. Soil Use Manage. 21:102-112.
27. Oelkers, E.H., J. Schott, J.-M. Gauthier and T. Herrero-Roncal. 2008. An experimental study of the dissolution mechanism and rates of muscovite. Geochim. Cosmochim and temperature on the kinetics of montmorillonite dissolution. Geochim. Cosmochim. Acta 73:3752-3766.
28. Schneider, A., L. Augusto and A. Mollier. 2016. Assessing the plant minimal exchangeable potassium of a soil. J. Plant Nutr. Soil Sci. 179:584-590.
29. Simonsson, M., S. Andersson, Y. Andrist-Rangel, S. Hillier, L. Mattsson and I. Öborn. 2007. Potassium release and fixation as a function of fertilizer application rate and soil parent material. Geoderma. 140:188-198.
30. Singh, B. and D. Schulze. 2015. Soil Minerals and Plant Nutrition. Nature Educ. Knowl. 6:1.
31. Steel, R.G., J. H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics: A biometrical approach. 3rd Ed. McGraw-Hill Book Co., New York.
32. Wilson, M. 2004. Weathering of the primary rock-forming minerals: processes, products and rates. Clay Miner. 39:233-266.
33. Xue, N.-n., Y.-m. Zhang, T. Liu and J. Huang. 2016. Study of the Dissolution Behavior of Muscovite in Stone Coal by Oxygen Pressure Acid Leaching. Metallurg. Material. Transaction. B. 47:694-701.
34. Zorb, C., M. Senbayram and E. Peiter. 2014. Potassium in agriculture–status and perspectives. J. Plant Physiol. 171:656-669.

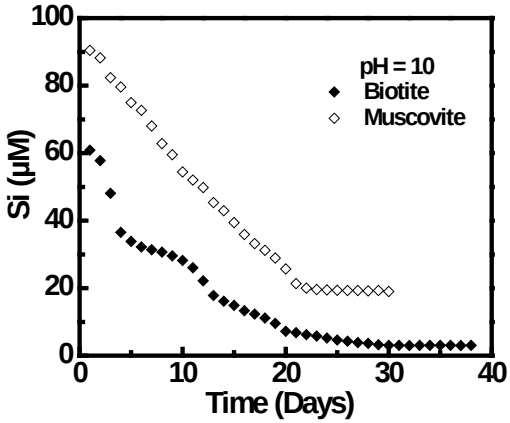
© 2018 Global Journals



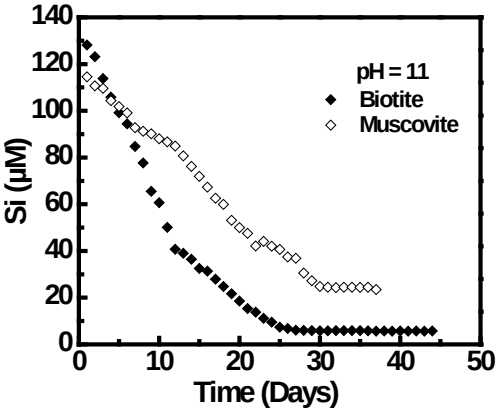
(a)



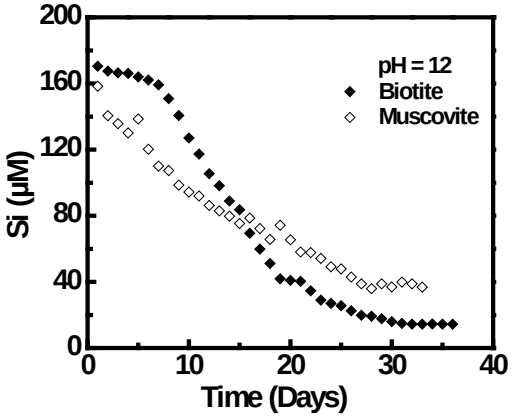
(b)



(c)



(d)



(e)

Figure 1: Silicon (Si) release from biotite and muscovite dissolution experiments at pH 8-12, 25°C

© 2018 Global Journals

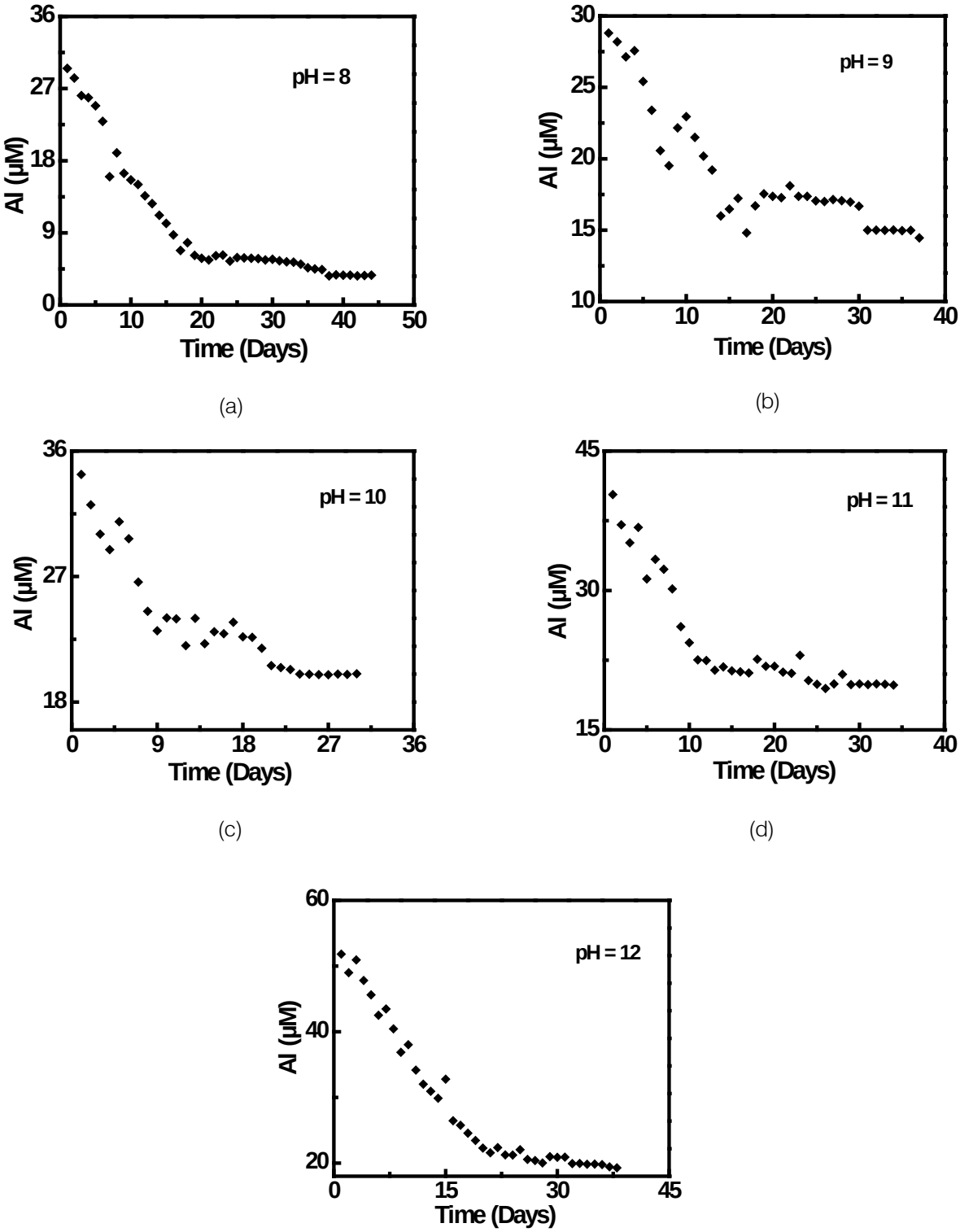


Figure 2: Aluminum (Al) release from muscovite dissolution experiments at pH 8-12, 25°C

© 2018 Global Journals

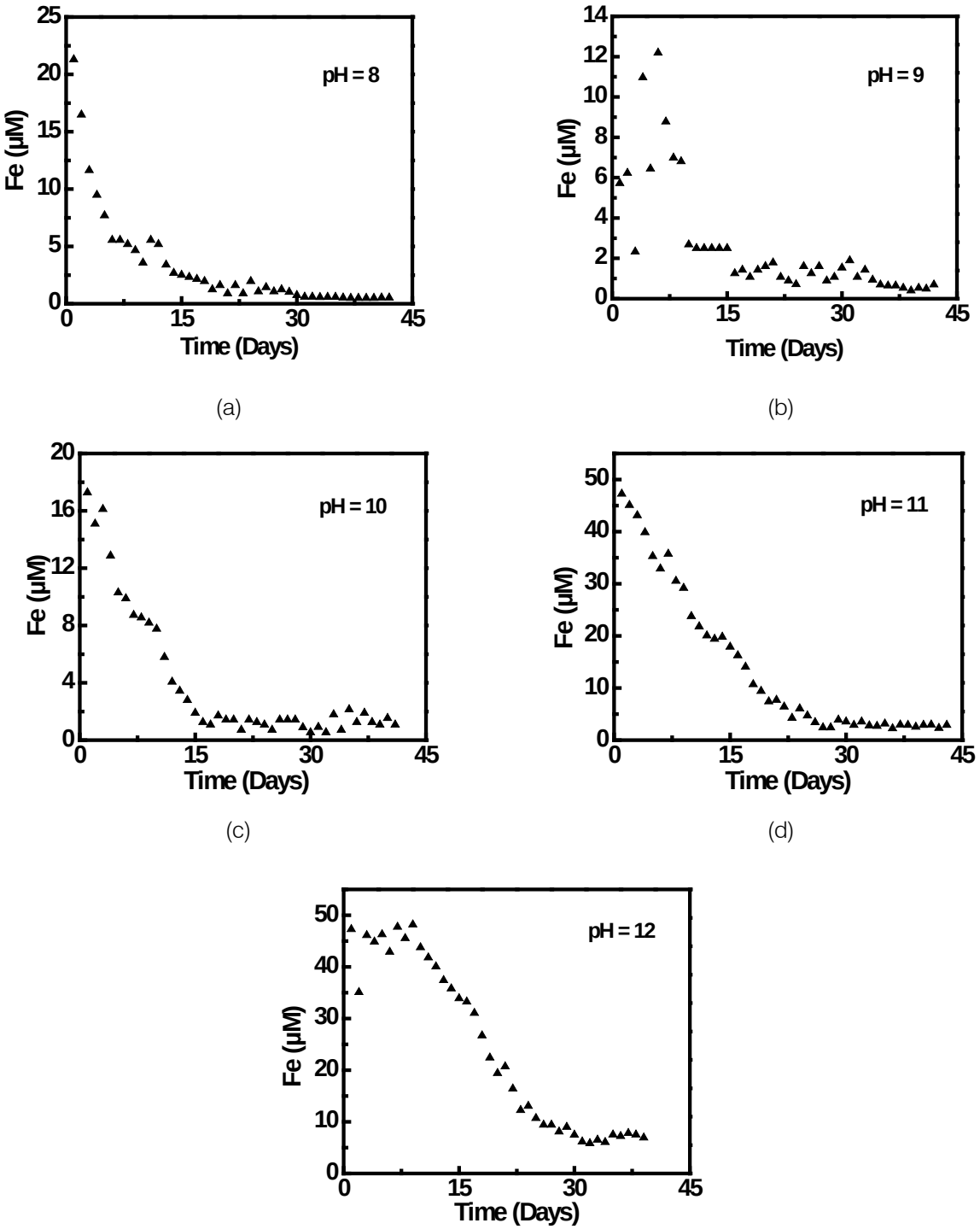


Figure 3: Iron (Fe) release from biotite dissolution experiments at pH 8-12, 25°C

© 2018 Global Journals

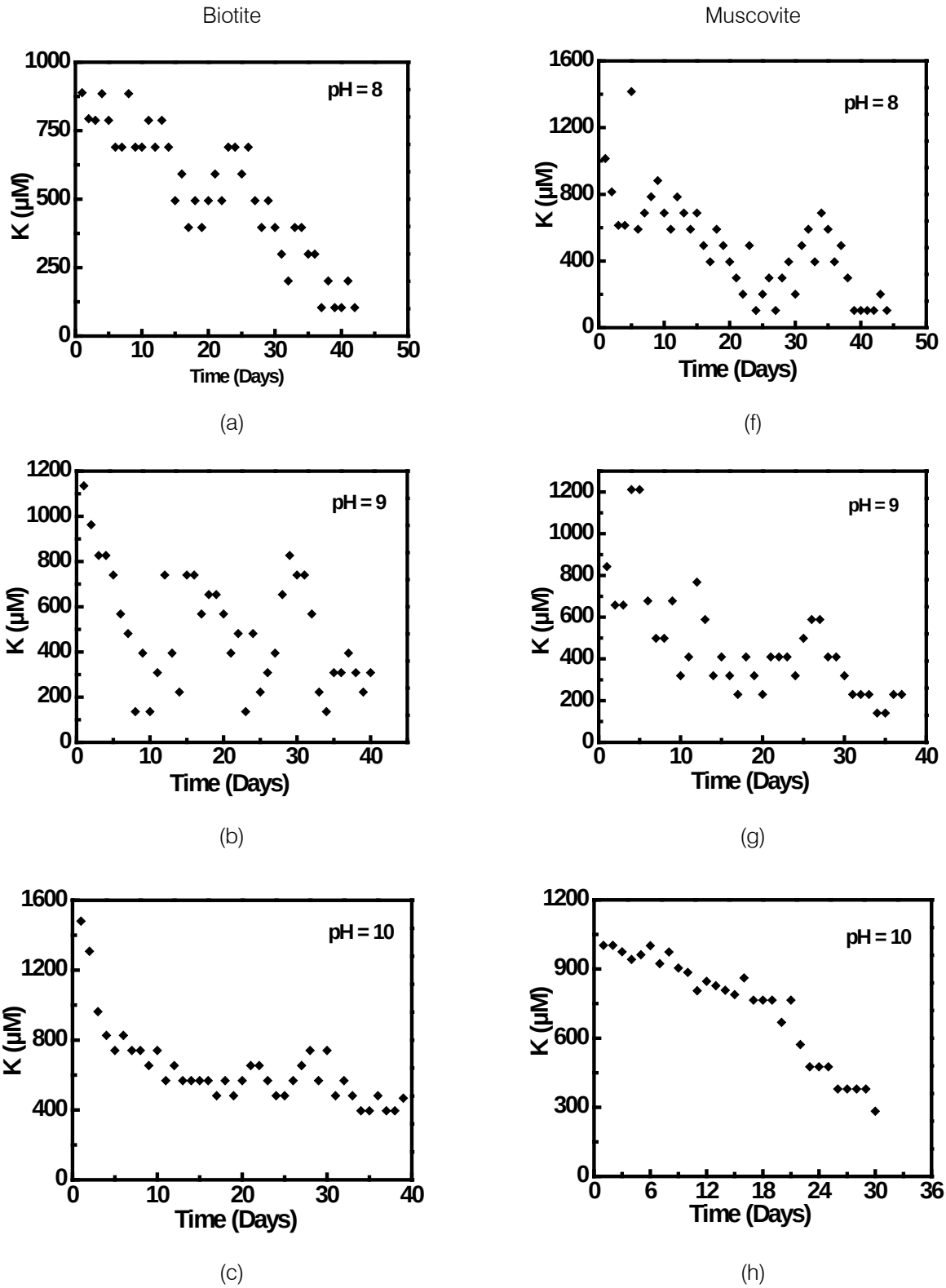


Figure 4: Potassium (K) release from biotite and muscovite dissolution experiments at pH 8-12, 25°C

© 2018 Global Journals

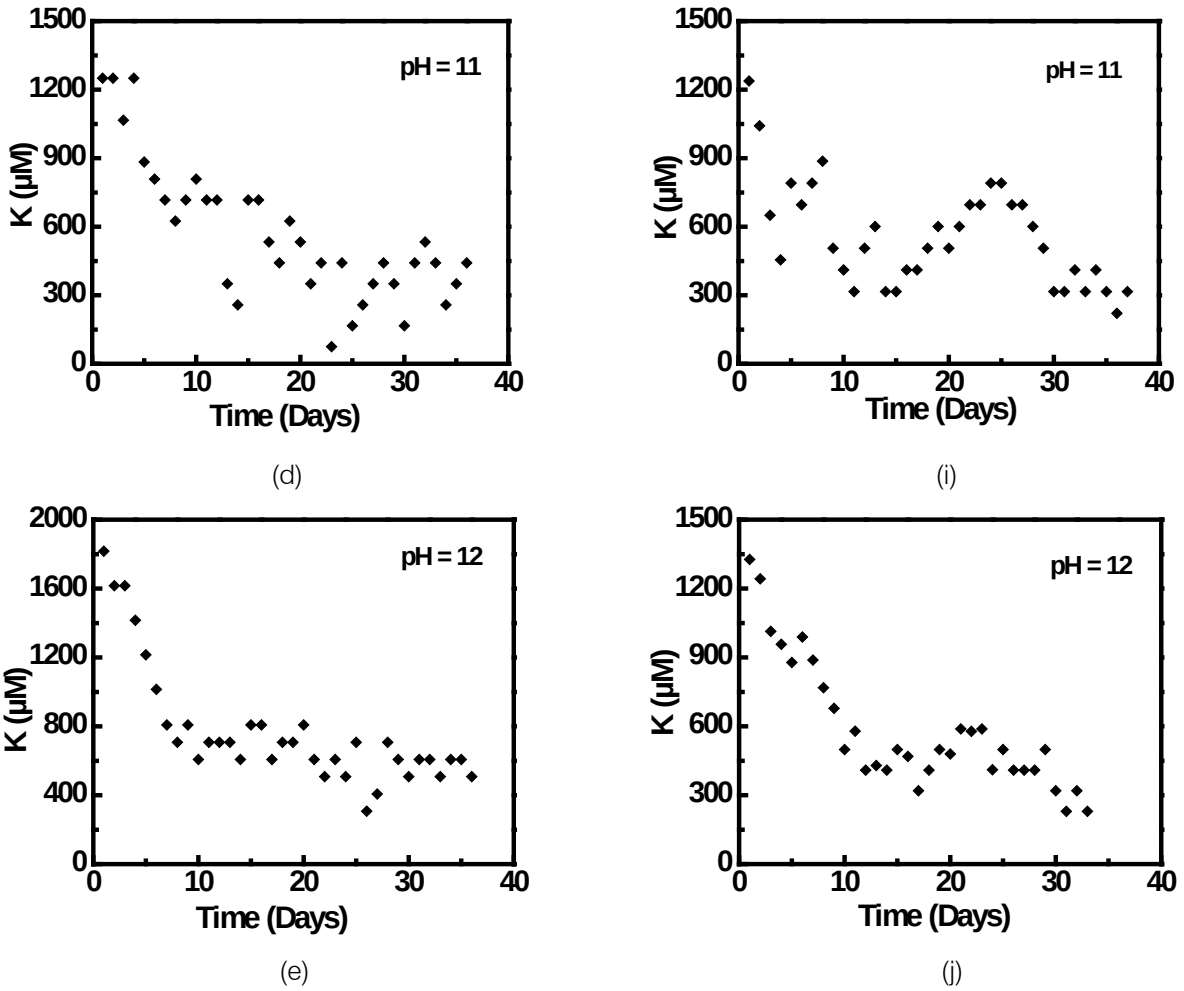


Figure 4: Potassium (K) release from biotite and muscovite dissolution experiments at pH 8-12, 25°C

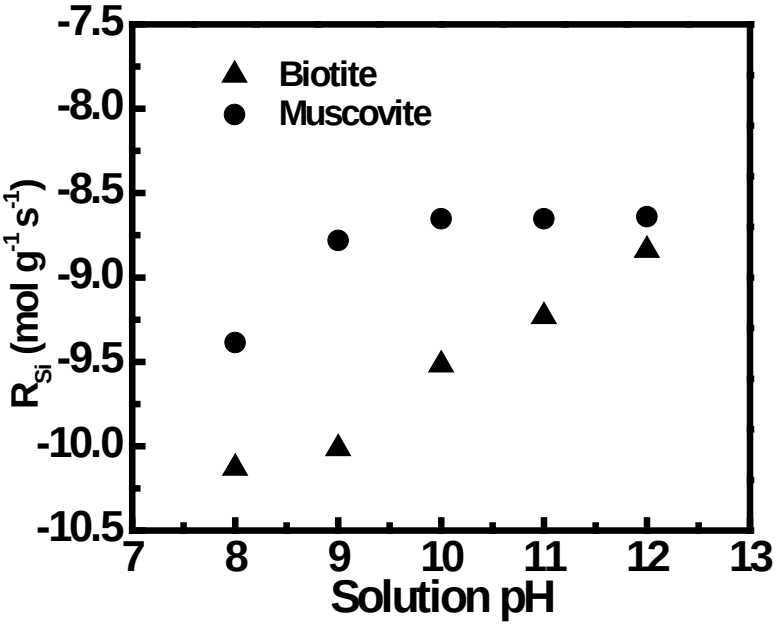


Figure 5: Comparative dissolution rates of biotite and muscovite based on Si release

© 2018 Global Journals

Table 1: Chemical composition of mica minerals

Composition	Biotite	Muscovite
SiO_2	37.93	47.29
Al_2O_3	14.09	33.74
Fe_2O_3	7.19	4.10
FeO	13.35	1.33
MnO	0.06	0.38
MgO	11.88	0.20
CaO	0.11	0.02
Na_2O	0.12	0.60
K_2O	9.35	10.91
TiO_2	3.16	0.21
F	0.06	0.20
Σ	97.30	98.98

Biotite,
$(Ca_{0.02}Na_{0.04}K_{1.82})(Al_{0.33}Fe^{3+}_{0.82}Fe^{+2}_{1.71}MnO_{0.01}Mg_{2.70})$
$(Si_{5.80}Al_{2.20})O_{20}(OH)_{3.97}F_{0.03}$

Muscovite,
$(Ca_{0.003}Na_{0.15}K_{1.82})(Al_{3.39}Fe^{3+}_{0.40}Fe^{+2}_{0.15}MnO_{0.04}Mg_{0.04})$
$(Si_{6.18}Al_{1.80})O_{20}(OH)_{3.91}F_{0.09}$
Ti omitted from the structural formulae.

© 2018 Global Journals

Global Journals Guidelines Handbook 2018

www.GlobalJournals.org

Fellows

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN SCIENCE (FARSS)

Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards "FARSS" title to individuals. The 'FARSS' title is accorded to a selected professional after the approval of the Editor-in-Chief/Editorial Board Members/Dean.

- The "FARSS" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSS or William Walldroff, M.S., FARSS.

FARSS accrediting is an honor. It authenticates your research activities. After recognition as FARSB, you can add 'FARSS' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

The following benefits can be availed by you only for next three years from the date of certification:

FARSS designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

Once FARSB title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA). The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.

You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The FARSS can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSS, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

The FARSS will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSS member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.
Once you are designated as FARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSS members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSS member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.

The FARSS is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSS can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSS member can decide its price and we can help in making the right decision.

The FARSS member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN SCIENCE (MARSS)

The ' MARSS ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The "MARSS" is a dignified ornament which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., MARSS or William Walldroff, M.S., MARSS.

MARSS accrediting is an honor. It authenticates your research activities. After becoming MARSS, you can add 'MARSS' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefitscan be availed by you only for next three years from the date of certification.

MARSS designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSS, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSS member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSS, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

AUXILIARY MEMBERSHIPS

Institutional Fellow of Global Journals Incorporation (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

Copyright

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

© Copyright by Global Journals | Guidelines Handbook

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

© Copyright by Global Journals | Guidelines Handbook

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

INDEX

Global Journal of Science Frontier Research

Visit us on the Web at www.GlobalJournals.org | www.JournalofScience.org
or email us at helpdesk@globaljournals.org

ISSN 9755896

© Global Journals