

JOURNAL OF SCIENCE AND TECHNOLOGY

Vol. 20, No. 2 (December 2022)

ISSN 1994-0386 (Print), 2959-3239 (Online)



Published by
Hajee Mohammad Danesh Science and Technology university (HSTU)
Dinajpur 5200, Bangladesh

JOURNAL OF SCIENCE AND TECHNOLOGY

Vol. 20, No. 2 (December 2022)

ISSN 1994-0386 (Print), 2959-3239 (Online)



Published by

Hajee Mohammad Danesh Science and Technology University (HSTU)

Dinajpur 5200, Bangladesh

Publication Time: 30 January 2023

JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN 1994-0386 (Print), 2959-3239 (Online)

Web: www.hstu.ac.bd

Hajee Mohammad Danesh Science and Technology University

Dinajpur-5200, Bangladesh

E-mail: editorjst.hstu@gmail.com; Phone: +88-01715204206

Vol. 20, No. 2 (December 2022)

EDITORIAL BOARD

Chief Editor

Professor Dr. M. Kamruzzaman

Vice-Chancellor, HSTU, Dinajpur

Editor

Professor Dr. Sripati Sikder

Department of Crop Physiology and Ecology, HSTU, Dinajpur

Associate Editor

Dr. Md. Shamim Hossain, Associate Professor

Department of Marketing, HSTU, Dinajpur

Members

Professor Dr. Fahima Khanam

Department of Economics, HSTU, Dinajpur

Professor Dr. Balaram Roy

Department of Chemistry, HSTU, Dinajpur

Professor Dr. Md. Kamal Uddin Sarker

Department of Agricultural and Industrial Engineering, HSTU, Dinajpur

Professor Dr. Bidhan Chandra Halder

Department of Horticulture, HSTU, Dinajpur

Professor Dr. Bikash Chandra Sarker

Department of Agricultural Chemistry, HSTU, Dinajpur

Professor Dr. S. M. Harun-Ur-Rashid

Department of Pathology and Parasitology, HSTU, Dinajpur

Professor Dr. Imran Parvez

Department of Fisheries Biology and Genetics, HSTU, Dinajpur

Professor Dr. Md. Mahabub Hossain

Department of Electronics and Communication Engineering, HSTU, Dinajpur

Professor Dr. Md. Jamal Uddin

Department of Marketing, HSTU, Dinajpur

Statement or ideas expressed in the papers of this Journal are the of authors, and the Editorial Board will accept no responsibility for those.

Subscription Rate

Each Issue: BDT 100/ USD 10 (individual);

BDT 200/ USD 20 (Institution)

Journal of Science and Technology

ISSN 1994-0386 (Print), 2959-3239 (Online)

Web: hstu.ac.bd

Hajee Mohammad Danesh Science and Technology University (HSTU)

Dinajpur 5200, Bangladesh

E-mail: editorjst.hstu@gmail.com; Cell Phone: 88-01715204206

Description

The Journal of Science and Technology ISSN 1994-0386 (Print), 2959-3239 (Online) is an official journal of Hajee Mohammad Danesh Science and Technology University. The journal has an international scope with broad constituency of scientists in the agricultural sciences, engineering, business studies, basic sciences and humanities, and annually publishes original articles, review papers and technical notes. A number of editorial members guide manuscripts through the review process and properly formatted papers are accepted for publication. Authors from all concerns of science and technology are requested to submit manuscripts for publication to this journal. We ensure speedy responses to authors and rapid publication, with all papers being reviewed by at least two independent referees.

Instructions for Authors

Manuscript preparation

Language: English

Spelling: The Journal uses UK spelling.

Units: All measurements must be given in SI or SI-derived units.

Abbreviations: Initially use the word in full, followed by the abbreviation in parentheses. Thereafter use the abbreviation only.

Scientific name: All papers must conform to the latest edition of the International Code of Botanical/Zoological Nomenclature. Upon its first use in the title, abstract and text, the common name of a species should be followed by the scientific name (genus, species and authority) in parentheses. Genus names should not be abbreviated at the beginning of paragraphs.

Structure of the manuscript: Manuscripts should be written in the following order: title page, abstract and key words, text, acknowledgements (if any), references, appendices (if any), figure and legends, tables (each table completes with title and footnotes).

Title page: The title page should contain -the title of the paper, the full names and addresses of the authors. The full name, designation, postal and email address plus telephone number of the correspondent for the manuscript should be sent. The corresponding author must be marked by putting asterisk (*) on his last name.

Title: The title should be short, informative and written in block letters. Abbreviations should not be used in the title. Example-

EVALUATION OF PHOTOSYNTHETIC POTENTIAL OF WHEAT GENOTYPES UNDER
DROUGHT CONDITION

Authors and affiliation: Include names of all authors, given first and middle initial (if any) and full family name (last name). Example-

S. Sikder^{1*}, J. Foulkes², H. West², J. De Silva², O. Gaju² and A. Greenland³

¹Department of Crop Physiology and Ecology

Hajee Mohammad Danesh Science and Technology University, Dinajpur 5200, Bangladesh

²School of Biosciences, University of Nottingham, Loughborough, LE12 5RD, UK

³ National school of Agricultural Botany, Cambridge, CB3 0LE, UK

*Corresponding author: Email: srisikder@gmail.com, Cell Phone: +8801715204206

Running title: A short running title (less than 50 characters) should also be provided. Example-Photosynthetic response of wheat to drought

Abstract: All articles must have a brief abstract that states in 250 words or fewer. The abstract must contain objective, basic procedures, main findings and principal conclusions of the study. The abstract should not contain abbreviations or references.

Key words: Four to eight key words should be supplied below the abstract. Example-Aging, fitness, sexual selection. Arrange in alphabetically.

Text: Authors should use the following sub-headings to divide the sections of their manuscript: Introduction, Materials and Methods/Methodology, Results and Discussion.

Format for text and citations: Doc format, Times New Roman font, 12 point, double space, separate paragraphs with a space, left justify the text and no page breaks. The authors should use block letters and bold style for titles of major sections (Abstract, Introduction, Materials and Methods/Methodology, Results and Discussion, Conclusion, Acknowledgments (if any) and References) and sub sections within major sections. The Methods and Results should be written in the past tense e.g. Percentage of protein in the cotton plant was determined by modified Kjaldahl method. The reference to tables and figures should be written in the present tense e.g. the data are shown in Table 1. The passive voice should be used but there are times when the active voice is more appropriate e.g. Figure 1 shows the results.

Therefore, the manuscript should be type with 2.5cm margins in all sides in A4 (21.0×29.7cm) offset papers. A manuscript for full paper should not exceed 12 typed pages including Figures, Graphs and Tables. In case of short communication, total typed page should be 6 (Six).

Acknowledgments: The source of financial grants and other funding may be acknowledged, including a frank declaration of the authors' industrial links and affiliations. The contribution of colleagues or institutions should also be acknowledged. Personal thanks and thanks to anonymous reviewers are not appropriate.

References in the text: Literature citations in the text should indicate the author's surname (last name) with the year of publication in parentheses e.g. Rahman (2000). If there are two authors, 'and' must be used between the two names e.g. Rahman and Khan (2006). When reference is made to a work by more than two authors, the first name followed by et al. should be used e.g. Roy *et al.* (2005). If there is more than one work by the same authors in the same year are cited, they should be distinguished by the letters a, b, c, etc.

Reference list: All references cited in the text, tables or figures must be listed as ascending alphabetical order.

The title of the work and name of the journal should be written in full. Examples of reference style are given below:

Journals

Evans LT and Dunstone RL.1970. Some physiological aspect of evolution in wheat. Australian Journal of Biological Sciences. 23:725-741.

Zalucki MP, Clarke AR and Malcolm SB. 2002. Ecology and behavior of first instar larval Lepidoptera. Annual Review of Entomology. 47: 361-393.

Books

Roff DA. 1992. The Evolution of Life Histories: Theory and Analysis. Chapman and Hall, New York, USA, pp. 339-343.

Wratten SD and Fry GIA. 1996. Field and Laboratory Exercises in Ecology. Edward Arnold, London, UK. pp. 98-103.

Chapter in a book

Dimetry NZ. 1988. Orientation to light by the lady bird beetle. In: Ecology and effectiveness of Aphidophaga (Ed. Niemczyk E and Dixon AFG). SPG Academic Publication, The Hague, The Netherlands, pp. 135-140.

Proceedings

Cunningham JP, Moore CJ, Zalucki MP and Cribb BW. 2004. Insect odour perception: recognition of odour components by flower foraging moths. Proceedings of the Royal Society of London B Biological Sciences. 273: 2035-2040.

Wittstock U, Agerbirk N, Stauber EJ, Olsen CE and Hippler M. 2004. Successful herbivore attack due to metabolic diversion of a plant chemical defense. Proceedings of the National Academy of Sciences of the USA. 101: 4859-4864.

Website

R Development Core Team. 2005. R: A Language and Environment for Statistical Computing: R Foundation for Statistical Computing. <http://www.R-project.org> Fields Development Team. 2006. Fields: tools for spatial data. National Center for Atmospheric Research, Boulder, CO. URL <http://www.cgd.ucar.edu/Software/Fields>.

Tables and figures: Tables and figures should be made in Excel and must be included at the end of the text.

Tables: Tables should be self-contained and complement and numbering should be made consecutively in the text in Arabic numerals. Each table should be set on a separate sheet with a concise legend above. The table legend and footnotes must be understandable without reference to the text. Statistical measures such as SD or SE should be identified in the headings. Example-

Table 1. Offspring production (mean $\pm$ SD) and sex ratio of *M. acastareared* on *B. terrestris* with different Foundresses

Foundress number	Offspring		Sex ratio
	Male	Female	
1	8.9 $\pm$ 3.09 c	295.1 $\pm$ 103.76 c	0.0308 $\pm$ 0.0095
2	17.45 $\pm$ 8.14 b	549.6 $\pm$ 173.11 ab	0.0303 $\pm$ 0.0086
3	22.75 $\pm$ 7.77 ab	673.65 $\pm$ 224.96 b	0.0337 $\pm$ 0.0112
4	39.15 $\pm$ 18.97 a	1023.7 $\pm$ 393.46 a	0.0366 $\pm$ 0.0119

Means within a column followed by same letter(s) are not significantly different by Tukey H.S.D. post hoc test ($p \leq 0.05$)

Figures: All line drawings and photographs are considered as figures. Figures should be cited in consecutive order in the text. Figures should be sized to fit within the column (80 mm) or the full text width (169 mm). Line figures should be supplied as sharp, black and white graphs or diagrams. Figure legends should be concise and the figure and its legend must be understandable without reference to the text. Example-

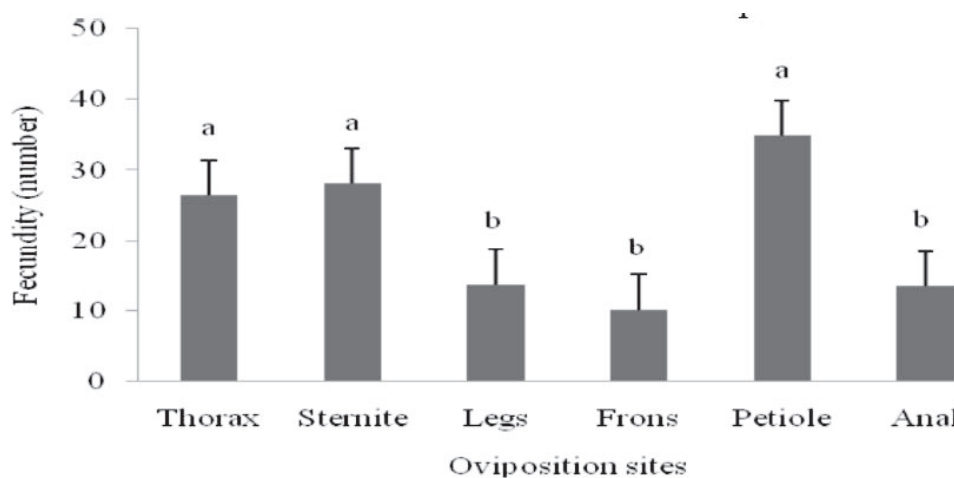


Figure 1. Fecundity (mean $\pm$ SD) of *M. acasta* on different oviposition sites of *B. terrestrispupae*. Bars with no column letter(s) are significantly different by Tukey H.S.D. post hoc test ($p < 0.05$).

Submission procedure

Authors are requested to submit new manuscripts to the editor as e-mail attachment (s) or hard copy in triplicate (after acceptance must submit soft copy).

Suggested reviewer

With a view to rapid review process authors are requested to send name and full postal address (including e-mail and telephone number) of seven persons.

Covering letter

Papers are accepted for publication in the Journal of Science and Technology on the understanding that the content has not been published or submitted for publication elsewhere except as a brief abstract in the proceedings of a scientific meeting or symposium. This must be stated in the covering letter. The covering letter must also contain an acknowledgment that all authors have contributed significantly, and that all authors are in agreement with the content of the manuscript.

Author fees

To cover reviewing expenditures, authors should send a fee of TK. 1000 accompany with the manuscript. On acceptance of the manuscript, an additional fee (TK. 500 for HSTU authors and TK. 1000 for other institutional authors) will be paid for publication. All fees will be paid to the editor, Journal of Science and Technology as cheque/demand draft/pay order.

Corresponding address to the editorial office

The Editor
 Journal of Science and Technology
 C/O Department of Crop Physiology and Ecology
 Hajee Mohammad Danesh Science and Technology University
 Dinajpur 5200, Bangladesh.
 E-mail: editorjst.hstu@gmail.com
 Phone: +88-01715204206

CONTENTS

Research articles	Page No.
<i>Agricultural Sciences</i>	
FOLIAR APPLICATION OF POTASSIUM AND GIBBERELLIC ACID (GA ₃) TO ALLEVIATE DROUGHT STRESS IN WHEAT M.N. Haque, S.K. Pramanik, M.A. Hasan M.R. Islam and S. Sikder	1-10
STUDY ON GROWTH AND YIELD OF OYSTER MUSHROOM AS INFLUENCED BY COMPOSTED SAWDUST BASED SUBSTRATES N. J. Nishi, M. H. Akand, A. J. Kakon and M. H. Rahman	11-19
EFFECT OF IRRIGATION FREQUENCY ON GROWTH AND YIELD OF SOYBEAN B. Sinha, M. Fahmida and M. S. Rahman	20-29
EFFECT OF SMOKING AS POST-HARVEST TREATMENT ON THE RIPENING AND QUALITY OF BANANA (<i>Musa</i> sp) M. H. Rahman, M. T. Aktar, M. A. Kabir, M. H. Rahman and M. T. Abedin	30-36
<i>Computer Science and Engineering</i>	
PERFORMANCE STUDY OF A WALKING TYPE 4-ROW MECHANICAL RICE TRANSPLANTER M. Fahmida, U. Habiba, M. S. Rahman and Milufarzana	37-47
DESIGN DEVELOPMENT AND PERFORMANCE EVALUATION OF SOLAR POWERED SPRAYER WITH WATER LEVEL INDICATOR S. Banu, Milufarzana, M. M. Haque, M. S. Islam and S. R. Roy	48-59
<i>Business Studies and Social Sciences</i>	
IMPACT OF FACTORS AFFECTING CUSTOMER SATISFACTION TOWARDS CORPORATE LOAN IN THE BANKING SECTOR OF BANGLADESH H. Begum, S. A. Khan and M. Aktar	60-67
INVESTIGATING THE IMPACT OF SERVICE DIMENSIONS ON CUSTOMER SATISFACTION AND CUSTOMER LOYALTY: A CONTEXT ON EMERGING SERVICE ECONOMY T. Islam, S. N. Habib, R. Islam, and R. Sharmin	68-75
THE IMPACT OF PACKAGING ON CONSUMER BUYING DECISION: AN APPLICATION ON CONSUMER GOODS M. J. Uddin, H. Begum and M.A. Rouf	76-81
POVERTY AND ETHNIC MINORITY IN BANGLADESH: A SOCIOLOGICAL INVESTIGATION ON CHAKMA COMMUNITY A. Mahmud and M. R. Islam	82-91
IMPACT OF CAPITAL STRUCTURE ON BANK PERFORMANCE: A STUDY ON JANATA BANK LIMITED OF BANGLADESH H. Begum*, S. Rimu and J. Ara	92-99



Journal of Science and Technology 20 (December 2022): 1-10

ISSN 1994-0386 (Print), 2959-3239 (Online)

**FOLIAR APPLICATION OF POTASSIUM AND GIBBERELIC ACID (GA₃) TO
ALLEVIATE DROUGHT STRESS IN WHEAT**

M. N. Haque, S. K. Pramanik, M. A. Hasan M. R. Islam and S. Sikder*

Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology
University, Dinajpur 5200, Bangladesh

*Corresponding author: Email: srisikder@gmail.com; Cell phone: +8801715204206

DOI:<https://www.doi.org/10.59125/JST.20201>

ABSTRACT

To investigate the ameliorative effect of foliar application of potassium and gibberellic acid on wheat to drought stress an experiment was conducted at the research field and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period of November 2018 to March 2019. The experiment was laid out in a split plot design with three replications. Four growing conditions viz. well water (WW), water deficit stress (WDS), foliar application of 2.23% K₂SO₄ under WDS and foliar application of 300 ppm GA₃ under WDS were set up as the main plot treatment and two wheat varieties (Kanchan and BARI Gom-30) were set up as sub plot treatment. Non-irrigated water stress significantly reduced different physiological traits, yield and yield attributes except proline content of flag leaf of wheat, whereas foliar application of potassium and GA₃ improved these traits under WDS. Foliar application of potassium improved biological yield (22.04% and 15.16%) and grain yield (3.19% and 2.59%) in Kanchan and BARI Gom-30, respectively, whereas foliar application of GA₃ improved biological yield (12.12% and 17.00%) and grain yield (1.47% and 1.18%) in Kanchan and BARI Gom-30, respectively under WDS. Though, foliar application of potassium and GA₃ ameliorated the adverse effect of drought on wheat but potassium was found more effective. Therefore, it may be concluded that additional foliar application of potassium along with recommended potassium could improve production of wheat under drought.

Key words: Drought tolerance, potassium, GA₃, physiology, yield, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second important cereal crop next to rice in Bangladesh (Barma *et al.* 2019). It is grown over an area of 0.33 million hectares with an annual production of about 1.03 million metric tons (BBS 2020). Still now, the average yield of the crop is comparatively low (3.09 t ha⁻¹) (BBS 2020) than other leading wheat growing countries of the world. Wheat production has been declined due to various abiotic stresses over the last two decades and drought is the most prominent one (Pramanik *et al.* 2021) which employs expressively adverse effects on production of wheat in northern and central part of the country (Abhinandan *et al.* 2018).

Drought or water deficit stress severely inhibits growth and productivity of wheat in comparison

with other environmental stresses (Zhang *et al.* 2018). It simultaneously affects morphological, physiological, biochemical, and metabolic changes (Cochard *et al.* 2002); disturbs membrane stability, plant metabolism and photosynthesis machinery (Nardino *et al.* 2022) and finally reduce yield performance. In developing countries, the water shortages have reduced wheat yields from 50 to 90% of their irrigated potential (Cochard *et al.* 2002). Therefore, for sustaining wheat yield, a high priority should be given to minimize the detrimental effects of water stress on crop production by applying modern breeding techniques, increasing physical and chemical fertility and maintaining adequate and balanced supply of mineral nutrients and growth regulators.

Potassium enhances drought tolerance in plants through mitigating harmful effects on translocation, osmoregulation, photosynthesis, transpiration, maintaining water balance, stomatal opening and closing and synthesis of protein (Cakmak 2005 and Milford and Johnston 2007). Plant suffering from drought stress required more internal potassium and potassium plays a vital role in improving the plant resistance (Cakmak 2005). Low grain yield resulting from water deficit could be overcome by increasing potassium supply (Aowan *et al.* 2012). Recent studies have reported that exogenous gibberellins (GA₃) regulate the level of active gibberellins in the plant and may have the role in plant abiotic stress response (Tonkinson *et al.* 1997). Exogenous application of GA₃ was found to overcome the inhibitory effect of abiotic stress in maize, mustard and wheat (Tuna *et al.* 2008 and Yang 2013). Exogenous application of potassium and GA₃ may be one of the important practices in ameliorating drought stress of wheat. Thus, the present investigation was carried out to investigate the effect of foliar supplying of potassium and GA₃ on wheat to ameliorate drought stress.

MATERIALS AND METHODS

Location and duration: The experiment was conducted at the research field and laboratory of Department of Crop Physiology and Ecology, HSTU, Dinajpur, Bangladesh during November, 2018 to March, 2019. The experimental field is located at 25°39' N latitude and 88°41' E longitude with an elevation of 37.58 meters above the sea level and under the Agro-ecological zone Old Himalayan Piedmont Plain (AEZ-1).

Experimental design layout and treatments: The experiment was laid out in a split plot design and replicated thrice. The unit plot size was 2m × 1.5m having a plot to plot and block to block distance of 0.75m and 1m, respectively. Four growing conditions: i) well water (irrigation was given at crown root initiation, anthesis and grain filling stages), ii) water deficit stress (no irrigation), iii) foliar application of 2.23% K₂SO₄ under water deficit stress and iv) foliar application of 300 ppm GA₃ under water deficit stress were placed in main plots, whereas two wheat varieties (Kanchan and BARI Gom-30) were placed randomly in sub plots. Well water plots were irrigated three times but the water stress plots were not irrigated throughout the growing period to maintain water deficit stress condition and the crop was protected from rainfall by taking polythene shelter.

Sowing of seeds and intercultural operations: Seeds were sown on 23 November, 2018 at the rate of 120 kg ha⁻¹ in rows of 20 cm apart. Slight irrigation was given after sowing to facilitate uniform germination. Recommended production technology of wheat was followed and necessary intercultural operations were done accordingly.

Haque *et al.* / Foliar application of K and GA₃ to alleviate drought stress in wheat

Preparation and application of potassium and GA₃: For 1% potassium fertilizer foliar application of 2.23% K₂SO₄ with 1% Tween 20 was sprayed. The GA₃ solution of 300 ppm concentrations was prepared by dissolving 300 mg of GA₃ in 10 ml methanol prior to dilution with distilled water. Then distilled water was added to make the volume 1 litre to get 300 ppm GA₃ solution. The foliar spraying was done at 40, 60 and 70 days after sowing with the help of a hand sprayer until all leaves were completely wetted.

Data collection on soil moisture content: Soil moisture content was calculated as dry weight basis from 15 cm depth soil using the formula; Soil moisture content (%) = {(Fresh weight of soil - Weight of oven dry soil) / Weight of oven dry soil} × 100

Data collection on physiological parameters

Relative water content (RWC) of flag leaf was measured at 16 days after anthesis according to Barrs and Weatherley (1962). Chlorophyll content of flag leaf was determined at 16 days after sowing according to Witham *et al.* (1986). A hand held infra-red thermometer was used to measure canopy temperature at 5 days after anthesis during noon period under bright sunlight and less wind. Canopy temperature depression (CTD) was calculated by calculating the difference between ambient air temperature and canopy temperature in degree centigrade. Proline content of flag leaf was determined at 16 days after sowing according to Bates *et al.* (1973).

Data collection on yield and yield contributing attributes: Plant height, spikes plant⁻¹, spikes m⁻², spike length, spikelets spike⁻¹, grains spike⁻¹, grains weight spike⁻¹, 500 grain weight, biological yield and grain yield were recorded manually from each of five sample plants from each replication at harvest.

Statistical analysis: For all investigated parameters, analysis of variance was performed by partitioning the total variance and the treatment means were compared using Tukey's test with the help of STATA (Small STATA 12.0) software package.

RESULTS AND DISCUSSION

Soil moisture content at different days after sowing

The column graph compares the soil moisture content of well water and water stress plots at 80, 90 and 100 days after sowing of seed. It indicates that well water plots maintained higher soil moisture (18.66%, 15.33% and 11.55%) than that of water stressed plots (12.57%, 7.53% and 5.55%). The variation might be due to different irrigation supply and variation in rate of evapotranspiration and consumption of water by plants from soil at early and later crop growth stages. Other authors also recorded remarkable variation in moisture content of well water and water deficit stressed plots of wheat (Ali *et al.* 2018), maize (Ray *et al.* 2020 and Haque *et al.* 2021) and mung bean (Ahmed *et al.* 2021) that clarify our findings.

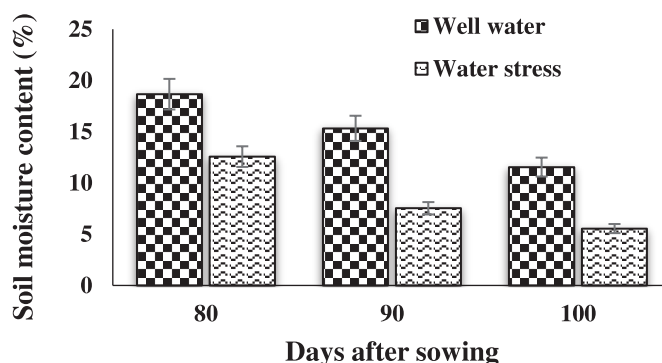


Figure 1. Soil moisture content (0-15 cm depth) at different days after sowing as influenced by water regimes.

Physiological traits

Relative water content, chlorophyll content and proline content of flag leaf and canopy temperature depression of wheat were significantly varied by the interaction effect of varieties and growing conditions (Table 1). The maximum water content of flag leaf (72.43%) was observed in BARI Gom-30 under WW, whereas minimum (61.66%) was observed in Kanchan under WDS. Water deficit stress reduced the water content of flag leaf in wheat at different magnitude (11.98% in Kanchan and 8.37% in BARI Gom-30). Water deficit stress reduced the chlorophyll content by 27.22% in Kanchan and 31.11% in BARI Gom-30. The well watered plots maintained comparatively cooler canopy than the water stressed plots. Water deficit stress reduced the cooling capacity of wheat canopy (21.52% in Kanchan and 24.64% in BARI Gom-30). Maximum proline content of flag leaf ($1.92 \mu\text{mole g}^{-1}$ FW) was observed in Kanchan under WDS, whereas the minimum ($1.37 \mu\text{mole g}^{-1}$ FW) was observed in BARI Gom-30 under WW. Water deficit stress increased the proline content of wheat varieties at different magnitude (38.13% in Kanchan and 36.50% in BARI Gom-30). Under WDS, improvement due to foliar application of potassium was observed by 11.03 and 8.33% in RWC of flag leaf, 31.65 and 22.82% in CC of flag leaf, 8.17 and 29.81% in CTD, whereas foliar application of GA_3 improved these traits by 3.28% and 7.98%, 2.80% and 19.21%, 5.86% and 29.13% in Kanchan and BARI Gom-30, respectively (Table 1). Under WDS, the proline content was reduced by foliar application of potassium and GA_3 . Potassium reduced the proline content by 19.79 and 7.49%, while GA_3 reduced by 16.67% and 6.95% in Kanchan and BARI Gom-30, sequentially.

In present investigation, we found that physiological traits of wheat are negatively affected by WDS. Significant reduction in photosynthetic pigment due to WDS was observed by Farshadfar *et al.* (2014) that is parallel to our findings. Proline is well known to rise dramatically in higher crop plants in response to different abiotic stresses like drought (Nowsherwan *et al.* 2018) which is in agreement with the present findings. Meaningful reduction in relative leaf water and chlorophyll content and dramatic rise of proline in wheat leaf were also observed by Pramanik *et al.* (2021) that supports our present findings. Wheat plants maintained comparatively a hot canopy

under WDS which might be due to low transpiration rate and reduced foliage as well as reduced canopy of plants under stress as plant shows diverse mechanisms to adapt unfavorable condition. Potassium plays a role as an enzyme stabilizing agent and has the ability to mediate osmotic adjustment (Sarwar *et al.* (2017). Physiological improvement was also observed due to foliar application of potassium (Mohammadi *et al.* 2013) and foliar application of gibberellic acid (Sarwar *et al.* 2017) that are supporting to our findings on physiological responses of wheat to potassium and GA₃.

Yield and yield components

Different yield components and yield except spikes plant⁻¹, grain weight spike⁻¹ and biological yield were significantly influenced by the interaction effect of varieties and growing conditions (Table 2 and 3). Detrimental effects of water deficit stress considerably reduced the yield and yield components of wheat but foliar application of potassium and GA₃ played significant role in compensating the negative effect of WDS and improving the yield traits. The tallest plant (99.69cm) was observed in Kanchan under WW condition, whereas the shortest plant (86.68cm) was observed in BARI Gom-30 under WDS. The longest spike (11.27cm) was observed in Kanchan which was statistically similar with that of BARI Gom-30 (11.10cm) under WW, whereas the minimum spike length (9.15cm) was observed in BARI Gom-30 under WDS. The maximum grains weight spike⁻¹ of wheat (2.37g) was observed in BARI Gom-30 under WW, whereas the minimum (1.77g) was observed in Kanchan under WDS. The maximum biological yield of wheat (8.77 t ha⁻¹) was recorded from BARI Gom-30 under WW, whereas the minimum (6.85 t ha⁻¹) was recorded from Kanchan under WDS. BARI Gom-30 produced the maximum grain yield (4.48 t ha⁻¹) under WW but the minimum grain yield (4.07 tha⁻¹) was observed in Kanchan under WDS. Water deficit stress reduced the plant height (3.84% in Kanchan and 12.15% in BARI Gom-30), spikes number plant⁻¹ (23.31% in Kanchan and 9.66% in BARI Gom-30), number of spikes m⁻² (12.79% in Kanchan and 14.97% in BARI Gom-30), grains spike⁻¹ (6.78% in Kanchan and 7.45% in BARI Gom-30), grain weight (18.81% in Kanchan and 10.55% in BARI Gom-30), 500 grain weight (4.45% in Kanchan and 1.37%) as compared to that of WW (Table 2 and 3). Under WDS, Kanchan constitutes 19.79% reduction in biological yield which is almost as similar as BARI Gom-30 which accounts for 19.49% reduction in biological yield. Kanchan made up 4.68% depletion and BARI Gom-30 accounts for 5.36% reduction in grain yield due to WDS. Foliar application of potassium amended the detrimental effect of WDS and recovered the loss by 1.94 and 1.38% in plant height, 14.04 and 9.26% in spikes plant⁻¹, 13.35 and 11.78% in spikes m⁻², 4.18 and 9.51% in spike length, 7.59 and 8.29% in spikelets spike⁻¹, 1.63 and 6.39% in grains spike⁻¹, 18.64 and 8.02% in grain weight spike⁻¹, 4.86 and 0.76% in 500 grain weight, 22.04 and 15.16% in biological yield and 3.19 and 1.18% in grain yield in Kanchan and BARI-Gom-30, respectively (Table 2 and 3). Foliar application of GA₃ compensated the loss of those traits by 3.94 and 9.33%, 11.32 and 6.89%, 2.60 and 3.25%, 0.56 and 6.99%, 3.79 and 4.80%, 0.76 and 6.30%, 3.75 and 0.36%, 12.12 and 17.00% 1.47 and 1.18% in Kanchan and BARI Gom-30, sequentially except grain weight spike⁻¹ (Table 2 and 3). Foliar application of GA₃ improved the grain weight spike⁻¹ by 4.52% in Kanchan but no improvement was found in BARI Gom-30 (Table 3).

Table 1. Interaction effect of varieties and growing conditions on different physiological traits of wheat

Wheat varieties	Growing conditions	RWC of flag leaf		CC of flag leaf			CTD		FLPC	
		%	% Change over WW	mg g ⁻¹ FW	% Change over WW	?	% Change over WW	μmole g ⁻¹ FW	% Change over WW	
Kanchan	WW	70.06abc	-	9.81a	-	23.70a	-	1.39ef	-	
	WDS	61.66d	-11.98	7.14c	-27.22	18.60bc	-21.52	1.92a	+38.13	
	WDS+Foliar K ₂ SO ₄	68.46abc (+11.03%)	-2.28	9.40a (+31.65)	-4.08	20.12b (+8.17)	-15.11	1.54de (-19.79)	+10.79	
	WDS+ Foliar GA ₃	63.68cd (+3.28%)	-9.09	7.34c (+2.80)	-25.18	19.69b (+5.86)	-16.92	1.60cd (-16.67)	+17.17	
	WW	72.43a	-	8.84ab	-	21.59ab	-	1.37f	-	
	WDS	65.69bcd	-8.37	6.09c	-31.11	16.27c	-24.64	1.87ab	+36.50	
BARI Gom-30	WDS+Foliar K ₂ SO ₄	71.16ab (+8.33%)	-1.76	7.48bc (+22.82)	-15.38	21.12ab (+29.81)	-2.13	1.73bc (-7.49)	+26.28	
	WDS+Foliar GA ₃	70.93ab (+7.98%)	-2.07	7.26c (+19.21)	-17.87	21.01ab (+29.13)	-2.69	1.74bc (-6.95)	+27.00	
Level of significance		*	*	*	*	*	*	*	*	
CV (%)		6.15		6.46		11.30		12.33		

In a column, values followed by the different letter(s) are significantly different from each other at P?5% level by Tukey. *significantly different at 5% level of probability. CV= Coefficient of variation. WW=Well water. WDS=Water deficit stress. RWC=Relative water content. CC=Chlorophyll content. CTD= Canopy temperature depression. FLPC= Flag leaf proline content. Values in parenthesis indicate % improvement over WDS in respective variety.

Haque *et al.* / Foliar application of K and GA₃ to alleviate drought stress in wheat

Table 2. Interaction effect of varieties and growing conditions on yield components of wheat

Wheat varieties	Growing conditions	Plant height		Spikes plant ⁻¹		Spikes m ⁻²		Spike length		Spikelets spike ⁻¹	
		cm	% Change over WW	Number	% Change over WW	Number	% Change over WW	cm	% Change over WW	Number	% Change over WW
Kanchan	WW	99.69a	-	6.22	-	372.33a	-	11.27a	-	19.13a	-
	WDS	95.87ab	-3.84	4.77	-23.31	324.66ab	-12.79	10.77ab	-4.44	17.66bc	-7.63
	WDS+Foliar	97.73ab	-1.97	5.44	-12.54	368.00a	-1.15	11.22a	-0.44	19.00a	-0.68
	K ₂ SO ₄	(+1.94)		(+14.04)		(+13.35)		(+4.18)		(+7.59)	
	WDS+Foliar	99.65a	-0.04	5.31	-14.63	332.00ab	-10.82	10.83ab	-3.90	18.33ab	-4.18
	GA ₃	(+3.94)		(+11.32)		(+2.60)		(+0.56)		(+3.79)	
BARI Gom-30	WW	98.67ab	-	4.66	-	349.33ab	-	11.10a	-	16.68cd	-
	WDS	86.68c	-12.15	4.21	-9.66	297.00b	-14.97	9.15c	-17.57	15.20e	-8.87
	WDW+Foliar	87.88c	-10.93	4.60	-1.29	332.00ab	-4.95	10.02abc	-9.73	16.46d	-1.26
	K ₂ SO ₄	(+1.38)		(+9.26)		(+11.78)		(+9.51)		(+8.29)	
	WDS+Foliar	94.77b	-3.94	4.50	-3.43	306.66ab	-12.20	9.79bc	-11.80	15.93de	-4.50
	GA ₃	(+9.33)		(+6.89)		(+3.25)		(+6.99)		(+4.80)	
Level of significance		*		NS		*		**		*	
CV (%)		5.36		14.88		9.77		7.93		8.24	

In a column, values followed by the different letter(s) are significantly different from each other at P?5% level by Tukey. *significantly different at 5% level of probability, **significantly different at 1% level of probability. NS=Not significant at 5% level of probability. CV= Coefficient of variation. WW=Well water. WDS=Water deficit stress. Values in parenthesis indicates % improvement over WDS in respective variety.

Table 3. Interaction effect of varieties and growing conditions on yield components and yield of wheat

Wheat varieties	Growing conditions	Grains spike ⁻¹		Grain weight spike ⁻¹		500 grain weight		Biological yield		Grain yield	
		Number	% Change over WW	g	% Change over WW	g	% Change over WW	(t ha ⁻¹)	% Change over WW	(t ha ⁻¹)	% Change over WW
Kanchan	WW	39.40b	-	2.18	-	25.10a	-	8.54	-	4.27abc	-
	WS	36.73c	-6.78	1.77	-18.81	23.48c	-4.45	6.85	-19.79	4.07c	-4.68
	WW+Foliar	37.33c	-4.24	2.10	-3.21	24.62b	-1.91	8.36	-2.11	4.20bc	-1.64
	K ₂ SO ₄	(+1.63)		(+18.64)		(+4.86)		(+22.04)		(+3.19)	
	WS+Foliar GA ₃	37.01c	-6.04	1.85	-14.68	24.36b	-2.95	7.68	-9.95	4.13bc	-3.28
		(+0.76)		(+4.52)		(+3.75)		(+12.12)		(+1.47)	
BARI Gom-30	WW	46.15a	-	2.37	-	22.60d	-	8.77	-	4.48a	-
	WS	42.71b	-7.45	2.12	-10.55	22.28d	-1.37	7.06	-19.49	4.24abc	-5.36
	WW+Foliar	45.44a	-1.52	2.29	-3.38	22.45d	-0.66	8.13	-7.26	4.35ab	-2.90
	K ₂ SO ₄	(+6.39)		(+8.02)		(+0.76)		(+15.16)		(+2.59)	
	WS+Foliar GA ₃	45.40a	-1.63	2.12	-10.13	22.36d	-1.06	8.26	-5.82	4.29abc	-4.24
		(+6.30)				(+0.36)		(+17.00)		(+1.18)	
Level of significance		**	NS	NS	**	**	NS	NS	**	**	**
CV (%)		9.45	9.98	4.69	10.64	3.36					

In a column, values followed by the different letter(s) are significantly different from each other at P?5% level by Tukey. **significantly different at 1% level of probability. NS=Not significant at 5% level of probability. CV= Coefficient of variation. WW=Well water. WDS=Water deficit stress. Values in parenthesis indicates % improvement over WDS in respective variety.

Haque *et al.* / Foliar application of K and GA₃ to alleviate drought stress in wheat

Spikes plant⁻¹, spikes m⁻², spike length, grains spike⁻¹, grain weight spike⁻¹ and 500 grain weight in wheat may have considered being most important yield contributing components that are positively correlated with final grain yield. In our present study, WDS dramatically declined all these yield components. These results are in accordance with the results of Pramanik *et al.* (2021) who found WDS significantly reduced spikes plant⁻¹, spike length, grains spike⁻¹, grains weight spike⁻¹ and finally biological yield plant⁻¹ and grain yield plant⁻¹. Plant height was decreased under water deficit condition which might be due to decreased in cell expansion as well as reduced cell division. Water deficit stress significantly reduced spike length results in a smaller number of spikelets spike⁻¹ and grains per spike⁻¹ which ultimately reduced grain yield (Anjum *et al.* 2011). Yield reduction in wheat due to water deficit stress was also found by Daryanto *et al.* (2017) and Pramanik *et al.* (2021). Zhang *et al.* (2018) also observed 25.00% and 27.50% reduction in wheat biomass and grain yield, respectively due to drought. These findings are very much consistent to our present findings. Our research findings reveal that foliar application of potassium and GA₃ significantly increased the physiological and yield attributes of wheat than that of water deficit stress. It might be due to improved physiological processes that eventually increases plant growth and development leading to increase in yield and yield components (Ibraheim and Mohsen 2015). Improvement of yield attributes under water deficit stress condition by foliar application of potassium and GA₃ was also reported by Mohammadi *et al.* (2013), Arabshahi *et al.* (2017), Rahman *et al.* (2014) and Mehri (2015) that support the results of the present study.

CONCLUSION

From the overall results of the present study, it may be concluded that foliar application of potassium and GA₃ had ameliorative effect on physiology, yield attributes and final yield of wheat under water deficit stress condition and potassium was more effective as compared to GA₃. Therefore, additional foliar application of potassium along with recommended potassium could improve wheat productivity under drought condition.

REFERENCES

- Abhinandan K, Skori L, Stanic M, Hickerson N, Jamshed M and Samuel MA. 2018. Abiotic stress signaling in wheat-an inclusive overview of hormonal interactions during abiotic stress responses in wheat. *Frontiers in Plant Science*. 9: 734.
- Ahmed MT, Islam MR, Pramanik SK, Sikder S and Hasan MA. 2021. Amelioration of adverse effect of drought stress on mung bean through supplemental agronomic practices. *The Agriculturists*. 19(1&2): 73-85.
- Ali SS, Sikder S and Pramanik SK. 2018. Effect of non-irrigated water stress on phenology and yield performance of wheat genotypes (*Triticum aestivum* L.). *South Asian Journal of Biological Research*. 1: 42-52.
- Anjum SA, Xie X, Wang L, Saleem MF, Man C and Lei W. 2011. Morphological, physiological and biochemical responses of plants to drought stress. *African Journal of Agricultural Research*. 6(9): 2026-2032.
- Aowan M, Raza S, Saleem MF, Anjum SA, Khaliq T and Wahid MA. 2012. Foliar application of potassium under water deficit conditions improved the growth and yield of wheat (*Triticum aestivum* L.). *Journal of Animal and Plant Science*. 22(2): 431-437.
- Arabshahi M, Mobasser HR and Rad MRN. 2017. Effect of drought stress and gibberellin on some characteristics of wheat. *Chemistry Research Journal*. 2(2): 154-158.
- Barma NCD, Hossain A, Hakim MA, Mottaleb KA, Alam MA, Reza MM and Rohman MM. 2019. Progress and challenges of wheat production in the era of climate change: a Bangladesh perspective. In: *Wheat production in changing environments*. Springer Publication, Singapore, pp. 615-679.
- Barrs HD and Weatherley PE. 1962. A re-examination of the relative turgidity technique for estimating water deficit in leaves. *Australian Journal of Biological Sciences*. 15(3): 413-428.
- Bates LS, Waldren RP and Teare ID. 1973. Rapid determination of free proline for water-stress studies. *Plant and Soil*. 39: 205-207.
- BBS. 2020. Yearbook of Agricultural Statistics, Bangladesh Bureau of Statistics (BBS), Statistics and

- informatics division, Ministry of Planning, Government of the people's republic of Bangladesh, Dhaka Bangladesh.
- Cakmak I. 2005. The role of potassium in alleviating detrimental effects of abiotic stresses in plants. *Journal of Plant Nutrition and Soil Science*. 168: 521-530.
- Cochard H, Coll L, Le Roux X and Améglio T. 2002. Unraveling the effects of plant hydraulics on stomatal closure during water stress in walnut. *Plant Physiology*. 128: 282-290.
- Daryanto S, Wang L and Jacinthe PA. 2017. Global synthesis of drought effects on cereal, legume, tuber and root crops production: A review. *Agricultural Water Management*. 179: 18-33.
- Farshadfar E, Ghasemi M and Rafii F. 2014. Evaluation of physiological parameters as a screening technique for drought tolerance in bread wheat. *Journal of Biodiversity and Environmental Science*. 4: 175-186
- Haque MN, Pramanik SK, Hasan MA and Sikder S. 2021. Evaluation of drought tolerance in hybrid maize based on selected morpho-physiological and yield traits. *Journal of Science and Technology*. 19: 20-31.
- Ibraheim SKA and Mohsen AAM. 2015. Effect of chitosan and nitrogen rates on growth and productivity of summer squash plants. *Middle East Journal of Agriculture*. 4(4): 673-681.
- Mehri S. 2015. Investigating the effect of gibberellic acid and kinetin hormones on proline, protein and carbohydrates of leaf soluble in maize hybrids under drought stress. *Cumhuriyet University Faculty of Science Journal*. 36(3): 1300-1949.
- Milford GFJ and Johnston AE. 2007. Potassium and nitrogen interactions in crop production. *Proceedings of the International Fertiliser Society*. 615: 23pp.
- Mohammadi MM, Maleki A, Siaddat SA and Beigzade M. 2013. The effect of zinc and potassium on the quality yield of wheat under drought stress conditions. *International Journal of Agriculture and Crop Science*. 6(16): 1164-1170.
- Nardino M, Perin EC, Aranha BC, Carpes ST, Fontoura BH, de Sousa DJP *et al.* 2022. Understanding drought response mechanisms in wheat and multi-trait selection. *PloS one*. 17: e0266368.
- Nowsherwan I, Shabbir G, Malik SI, Ilyas M, Iqbal MS and Musa M. 2018. Effect of drought stress on different physiological traits in bread wheat. *SAARC Journal of Agriculture*. 16(1): 1-6.
- Pramanik SK, Sikder S and Hasan MA. 2021. Wheat physiology and yield as affected by water deficit stress. *The Agriculturists*. 19(1&2): 21-33.
- Rahman M, Rahman MM, Hasan MM, Begum F and Sarker MAZ. 2014. Effect of foliar application of potassium orthophosphate on grain yield and kernel quality of wheat (*Triticum aestivum*) under terminal heat stress. *Bangladesh Journal of Agricultural Research*. 39(1): 67-77.
- Ray UK, Sikder S, Bahadur MM and Pramanik SK. 2020. Morpho-phenological and yield responses of maize (*Zea mays* L.) to non-irrigated water stress condition. *Journal of Science and Technology*. 18: 8-15.
- Sarwar N, Farooq O, Mubeen K, Wasaya A, Nouman W, Ali MZ, and Shehzad M. 2017. Exogenous application of gibberellic acid improves the maize crop productivity under scarce and sufficient soil moisture condition. *Cercetari Agronomice in Moldova*. 50(4): 65-73.
- Tonkinson CL, Lyndon RF, Arnold GM and Lenton JR. 1997. The effects of temperature and the *Rht3* dwarfing gene on growth, cell extension, and gibberellin content and responsiveness in the wheat leaf. *Journal of Experimental Botany*. 48: 963-970.
- Tuna AL, Kaya C, Dikilitas M and Higgs D. 2008. The combined effects of gibberellic acid and salinity on some antioxidant enzyme activities, plant growth parameters and nutritional status in maize plants. *Environmental and Experimental Botany*. 62: 1-9.
- Witham FH, Blaydes DF and Devlin RM. 1986. *Exercise in Plant Physiology* (2nd edition), Prindle Weber and Schmidt Publishers, Boston, USA. pp. 128-131.
- Yang W, Duan L, Chen G, Xiong L and Liu Q. 2013. Plant phenomics and high throughput phenotyping: accelerating rice functional genomics using multidisciplinary technologies. *Current opinion in plant biology*. 16(2): 180-187.
- Zhang J, Zhang S, Cheng M, Jiang H, Zhang X, Peng C, Lu X, Zhang M and Jin J. 2018. Effect of drought on agronomic traits of rice and wheat: a meta-analysis. *International Journal of Environmental Research and Public Health*. 15(5): 839.



STUDY ON GROWTH AND YIELD OF OYSTER MUSHROOM AS INFLUENCED BY
COMPOSTED SAWDUST BASED SUBSTRATES

N. J. Nishi¹, M. H. Akand¹, A. J. Kakon² and M. H. Rahman^{3*}

¹Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh,
²Mushroom Development Institute, Savar, Dhaka, Bangladesh, ³Department of Horticulture, Hajee
Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh.

*Corresponding author: Email: hassan@hstu.ac.bd; Cell Phone: +8801719468999

DOI:<https://www.doi.org/10.59125/JST.20202>

ABSTRACT

An experiment was carried out in the laboratory of the Mushroom Development Institute, Savar, Dhaka from July to December 2019 to determine the effect of the sawdust composting period on the yield and yield attributes of different oyster mushroom varieties. The experiment was laid out by following Completely Randomized Design (CRD) with three replications. Three varieties viz. V₁ (*Pleurotus djamor*), V₂ (*Pleurotus ostreatus*) and V₃ (*Pleurotus florida*) with six different days of composted sawdust such as T₀ (0 days), T₁ (5 days), T₂ (10 days), T₃ (15 days), T₄ (20 days), T₅ (25 days) and T₆ (30 days) were used in this study. The effect of different mushroom varieties and composted period of sawdust showed significant variation in growth and yield parameters. The results revealed that the highest number of the fruiting body, the effective fruiting body and biological yield were found in V₂, whereas the lowest numbers were observed in V₃. Besides, the maximum yield, the highest number of fruiting bodies and effective fruiting body were observed in T₃. Moreover, the maximum yield (56.50 g) was produced by V₂T₃ combination, and the minimum yield (38.13g) was produced by V₃T₂. The highest biological efficiency (32.28 %) was obtained in V₂T₃, whereas the lowest biological efficiency (21.78%) was obtained in V₃T₂ sawdust. This study suggests that *Pleurotus ostreatus* and 15 days composted sawdust showed the best performance.

Key words: Biological efficiency, fruiting body, oyster mushroom, sawdust compost, yield

INTRODUCTION

The oyster mushroom (*Pleurotus* spp) is in third place among the world's edible mushroom production (Gyorfi and Hajdu 2007). Oyster mushroom is the most suitable one for year-round production in Bangladesh due to a wide range of temperatures and available growing media, lower production cost. The fresh mushroom contains a considerable amount of nutrients and has some medicinal properties. The increased production of oyster mushrooms is a feasible solution to malnutrition experienced in most developing countries like Bangladesh. The culture of oyster mushroom (*Pleurotus* spp.) is becoming popular throughout the world due to the utilization of various lignocellulose species having extensive enzyme systems capable of digesting complex organic compounds. Cereal bran rich in protein is usually added to the substrate in oyster mushroom cultivation to stimulate mycelial growth and increase the yield of mushrooms (Kinugawa *et al.* 1994). Any agricultural waste that contains cellulose and lignin is a possible substrate for growing these fungi. On saw dust, the yield and efficiency were better than other

agro-based substrates; the mushroom fruiting bodies were revealed larger in size (Moonmoon *et al.* 2010). In Bangladesh, sawdust is produced on a large scale by the saw-mill industries as a byproduct. Therefore, it is a readily available and preferred as a medium for mushroom production.

Fermented substrate materials enhanced the weight and size of the fruit cap, fruiting bodies yield and produced quality fruiting bodies of mushroom (Choi 2004, Mohamed *et al.* 2016). However, the effect of different durable of composted sawdust on growth and yield of various mushroom species has not been studied yet in Bangladesh. Additionally, if the right composting time is established for mushroom variety the efficiency of the production of mushroom can be promoted. Considering the above facts present investigation was undertaken to find out the best species and composting period for ensuring the maximum yield of oyster mushrooms.

MATERIALS AND METHODS

Experimental materials and design: The experiment was conducted in the laboratory and culture house of the Mushroom Development Institute, Savar, Dhaka from July to December 2019. The experiment was laid out in a completely randomized design (CRD) with three replications. Three varieties of oyster mushrooms ($V_1 = \textit{Pleurotus\ djamor}$, $V_2 = \textit{Pleurotus\ florida}$ and $V_3 = \textit{Pleurotus\ ostreatus}$) were grown on different days of composted sawdust ($T_0 = 0$ days, $T_1 = 5$ days, $T_2 = 10$ days, $T_3 = 15$ days, $T_4 = 20$ days, $T_5 = 25$ days, $T_6 = 30$ days).

Preparation of pure and mother culture: Pure cultures and mother cultures of three species were prepared according to Sarker *et al.* (2017).

Sawdust composting for mushroom cultivation: The sawdust was cleaned and air-dried. Water was added to those until the moisture level reach about 70%, using the thumb test and made a heap of 1m^3 on the floor, then covered with polythene sheet. The sawdust was composted in six groups with composting times of 5, 10, 15, 20, 25 and 30 days.

Preparation of spawn: The substrate of spawn packets was prepared using composted sawdust and 5% wheat bran. Maintain a moisture level about 65% and CaCO_3 (0.2%, w/w) was added to the mixture. The substrate mixture was poured into 18 cm $\times$ 25 cm polypropylene bags at 500g/bag. A hole of about 2/3 deep of the bag was made for space to introduce the inoculum. The packets were sterilized in an autoclave for 2 h at 121°C under 1.1 kg cm^{-2} pressure. The cultures were incubated at 22°C for 12 hours per day under the light of cool white fluorescent bulbs. After completing mycelium growth, "D" shaped cut was done on shoulder of plastic bag and scraped slightly with a blade for removing the thin whitish mycelial layer.

Culture conditions for fruiting: The relative humidity (70-85%) and temperature ($22\text{-}27^\circ\text{C}$) was maintained in the culture chamber for all the treatment. Fruiting bodies of mushroom were picked around a week following pinhead formation when the gills were fully formed, and the caps' edges were still curled under.

Data collection: Data were collected on mycelium growth rate (MGR) (cm day^{-1}), time required to completion of mycelium running (days), primordial initiation (days) and pinhead initiation to 1st harvest (days), number of fruiting body, number of effective fruiting body, thickness of pileus (cm), diameter of pileus (cm), length of stipe (cm), diameter of stipe (cm) and biological yield (1st flush). Biological efficiency (%) was calculated using the following formula: Biological efficiency (%) = [(biological yield) / (total dried substrate used)] $\times 100$

Statistical analysis: Data were analyzed using the MSTAT-C computer program and excel software. Mean separation was computed following Least Significant Difference (LSD) using the same computer program.

RESULTS AND DISCUSSION

Mycelium growth rate: Mycelium growth rate was significantly influenced by oyster mushroom varieties and days of composted sawdust and also their combination effect varied significantly (Table 1, 2). The highest growth rate (0.54 cm) of mycelium was observed in V_2 (*P. florida*) and lowest (0.45 cm) was recorded in V_3 (*P. ostreatus*). The maximum mycelium growth rate (0.67 cm) was found in T_3 whereas the minimum rate was found in T_0 (0.45 cm) which is statistically similar to all other treatments. Also, the highest mycelium growth rate (0.68 cm) was recorded in treatment combination of V_1T_3 . The lowest mycelium growth rate was recorded in V_3T_0 (0.27 cm). Different composted substrate showed different mycelium running because of different carbohydrate based on availability and the environment of the spawn (Mondal *et al.* 2010).

Table 1. Effect of variety and period of composted sawdust on growth parameters of oyster mushroom

Treatment	Mycelium growth rate (cm/day)	Time required to completion of mycelium running (days)	Time required for primordial initiation (days)	Time required from pinhead initiation to 1st harvest (days)
Variety				
V_1	0.53a	21.29b	7.14b	4.52bc
V_2	0.54a	21.71ab	7.33ab	4.66bc
V_3	0.45b	22.00a	7.57a	4.85a
LSD (0.05)	0.01	0.6218	0.32	0.52
Days of composted sawdust				
T_0	0.45b	21.33cd	7.88a	4.11bc
T_1	0.45b	21.56bcd	7.77ab	4.66abc
T_2	0.52b	20.78d	7.33bc	5.22a
T_3	0.67a	20.56d	6.66d	3.77c
T_4	0.46b	22.44ab	7.22c	5.11ab
T_5	0.50b	22.00bc	7.33bc	4.77abc
T_6	0.51b	23.00a	7.22c	5.11 ab
LSD (0.05)	0.02	0.94	0.50	0.41
CV (%)	6.16	4.65	7.27	9.32

In a column, means followed by a common letter are not significantly differed at 5% level by DMRT. V_1 = *Pleurotus djamor*, V_2 = *Pleurotus florida*, V_3 = *Pleurotus ostreatus*, T_0 = 0, T_1 = 5, T_2 = 10, T_3 = 15, T_4 = 20, T_5 = 25, T_6 = 30

Time required to completion of mycelium running: The influence of mushroom varieties and days of composted sawdust, and their combination caused a significant difference in completion of mycelium running (Table 1, 2). The study revealed that maximum days (22.0) was required for the completion of mycelium running was in V_3 and the minimum (21.29) days required from V_1 . Vetayasuporn (2007) reported that *Pleurotus ostreatus* completed spawn running in 17-20 days on coconut substrates. The highest (23.0) and lowest (20.56) days required for the completion of mycelium running were found in T_6 and T_3 respectively. The combined treatment of V_2T_4 and V_3T_6 took the maximum time (23.67 days) to complete mycelium running, whereas the combinations of V_1T_2 took the minimum period (19.00 days). This variation could, in turn, be

attributed to the variations in chemical composition and Carbon to Nitrogen ratio (C: N) of the substrates (Okhuoya *et al.* 2005).

Table 2. Combined effect of variety and period of composted sawdust on growth parameters of oyster mushroom

Treatments	Mycelium growth rate (cm/day)	Time required to completion of mycelium running (days)	Time required for primordial initiation (days)	Time required from pinhead initiation/opening to 1st harvest (days)
V ₁ T ₀	0.54bc	21.67bcde	7.66abc	4.00cd
V ₁ T ₁	0.49bcd	21.67bcde	7.00bc	3.33d
V ₁ T ₂	0.50bcd	19.00g	7.33 abc	5.33ab
V ₁ T ₃	0.68a	19.67fg	6.00de	4.00cd
V ₁ T ₄	0.42efg	22.33abcd	7.33abc	4.66bc
V ₁ T ₅	0.52bc	22.67abc	7.66abc	5.00ab
V ₁ T ₆	0.53bc	22.00abcd	7.00bc	5.33ab
V ₂ T ₀	0.52bc	20.00efg	7.66abc	3.33d
V ₂ T ₁	0.48cd	22.00abcd	8.00ab	5.67a
V ₂ T ₂	0.52bc	22.67abc	7.33abc	5.33ab
V ₂ T ₃	0.67a	19.67fg	5.66e	3.33d
V ₂ T ₄	0.55b	23.67a	7.33abc	5.33ab
V ₂ T ₅	0.52bc	20.67defg	7.67abc	4.66bc
V ₂ T ₆	0.55b	23.33ab	7.67abc	5.00ab
V ₃ T ₀	0.27h	22.33abcd	8.33a	5.00ab
V ₃ T ₁	0.37g	21.00cdef	8.32a	5.33ab
V ₃ T ₂	0.54b	20.67defg	7.33abc	5.00ab
V ₃ T ₃	0.66a	22.33abcd	8.31a	4.00cd
V ₃ T ₄	0.41fg	21.33cdef	7.00bc	5.00ab
V ₃ T ₅	0.48 cde	22.67abc	6.66cd	4.66bc
V ₃ T ₆	0.45def	23.67a	7.00bc	5.00ab
LSD (0.05)	0.051	1.645	0.87	0.71
CV (%)	6.16	4.65	7.27	9.32

In a column, means followed by a common letter are not significantly differed at 5% level by DMRT. V₁= *Pleurotus djamor*, V₂= *Pleurotus florida*, V₃= *Pleurotus ostreatus*, T₀= 0, T₁= 5, T₂= 10, T₃= 15, T₄= 20, T₅= 25, T₆= 30

Time required for primordial initiation: Time required for primordial initiation showed a noticeable difference due to oyster mushroom varieties and days of composted sawdust, and their combination (Table 1, 2). The highest time (7.57 days) was needed for primordial initiation in V₃, which was statistically similar to V₂ (7.33 days) and the lowest time (7.14 days) was reported in V₁. Table- 1 also indicated that T₀ (7.88 days) had the maximum value, which was statistically similar to T₁ (7.77 days) whereas, minimum time requirement was found in T₃ (6.66 days). Combined treatment of V₃T₀ required the highest time (8.33 days) for primordial initiation, which was statistically similar to most of the studied treatment combinations, on the other hand the lowest time requirement (5.66 days) was observed in V₂T₃.

Time required from pinhead initiation to 1st harvest: Different mushroom varieties and days of composted sawdust, and their combination effect had a significant impact on the days required

Nishi *et al.*/ Growing oyster mushroom on composted sawdust substrate

from pinhead initiation to the first harvest (Table 1, 2). Maximum days (4.85 days) was observed in V₃ and the minimum period (4.52 days) was noticed in V₁. The maximum period was required from pinhead initiation to first harvest in T₂ (5.22 days) and lowest value was observed in T₃ (3.77 days). In Table 2, the maximum days from pinhead initiation to first harvest (5.67 days) were required in V₂T₁ and the V₂T₃ showed the shortest time (3.33 days). For the growth and penetration of the mycelium into basal substrates which ultimately influences fruiting bodies of mushrooms, the structure and porosity levels (oxygen availability) of substrate are important factors to be considered by Philippoussis *et al.* (2002).

Number of fruiting body and effective fruiting body: The number of the total fruiting body and effective fruiting body significantly varied among the oyster mushroom varieties and days of composted sawdust, and in the combination of those (Table 3, 4). The highest number of total fruiting body (13.97) was found in V₂ which was statistically similar to V₁ (13.46) and the lowest number was found in V₃ (4.36). Sarker *et al.* (2007) reported that *Pleurotus ostreatus* produced maximum number of fruiting bodies. The maximum number (11.57) of total fruiting bodies was found in T₃, whereas the minimum number (9.17) was found in T₂. Sarker *et al.* (2007) found similar results and stated that total carbon (C), nitrogen (N) and Carbon/Nitrogen ratio (C/N) are important factors that determined the mycelium colonization and development of fruiting bodies in oyster mushroom. The highest number of the total fruiting body was recorded in treatment combination of V₁T₃ (15.26). The lowest number of was recorded in V₃T₄ (3.26). In addition, the maximum number of effective fruiting body (11.43) was found in V₂ which was statistically similar to V₁ (10.92). The lowest number of the effective fruiting body (2.54) was found in V₃. The topmost number of the effective fruiting body was found in T₃ (9.21). The lowest number of the effective fruiting body (6.72) was found in T₂. This variation in number of the effective fruiting body in different aged compost could be due to the variations in chemical composition and carbon-nitrogen ratio (C: N) of the compost used (Bhatti *et al.* 2007). With the combined effect of mushroom varieties and days of composted sawdust, the number of the effective fruiting body significantly differed (Table 4). The maximum number of effective fruiting bodies (12.46) was found in V₂T₃, while the minimum number of effective fruiting bodies (1.73) was found in V₃T₅.

Thickness and diameter of pileus (cm): Thickness and diameter of pileus was significantly influenced by the combined effect of oyster mushroom varieties and days of composted sawdust, whereas it was not significantly influenced by the main effect of days of composted sawdust (Table 3, 4). The highest thickness (0.70 cm) was found in V₂ which was statistically similar to V₁ (0.64 cm) and the lowest thickness (0.62 cm) of pileus was found in V₃. The highest pileus thickness was found in T₅ (0.73 cm) and lowest was found in T₂ (0.62 cm) and T₆ (0.62 cm). In V₂T₃, the pileus was found to be the thickest (0.81 cm). In the combination V₃T₃, (0.40 cm) the pileus was found to be the thinnest. Here *Pleurotus ostreatus* and 15 days old, composted sawdust gave best result. Pileus thickness might be higher due to the presence of adequate nutrient in the substrates. As it is a yield attributing character so the higher thickness of pileus may increase the yield. Table 3 showed that the pileus with the largest dimension (10.79 cm) was found in V₃. Variety V₂ has the lowest pileus diameter (6.47 cm). Different genetic makeup of different varieties gave varied result. The pileus with the largest diameter was found in T₂ (10.98 cm). Twenty days of composted sawdust had the smallest pileus diameter (6.07 cm). The treatment combination of V₃T₂ had the largest pileus diameter (13.53 cm), which was statistically similar to V₃T₆ (13.27 cm). The pileus with the smallest (5.11 cm) diameter was found in V₁T₆. Use of compost can increase soil organic matter and water holding capacity and provide slow releasing nutrients to crops, which can lead to long-term yield increases (Dhanker 2019).

Length and diameter of stipe (cm): The length and diameter of the stipe was greatly diverged by the influence of different varieties and days to composted sawdust shown in Table 3, 4.

Table 3. Effect of variety and period of composted sawdust on yield attributing characters of oyster mushroom

Treatment	Fruiting body (No.)	Effective fruiting body (No.)	Thickness of Pileus (cm)	Diameter of Pileus (cm)	Length of Stipe (cm)	Diameter of stipe (cm)	Biological yield (1 st flush) (g)
Variety							
V ₁	13.46a	10.92a	0.66ab	6.65b	2.06c	1.18b	49.01b
V ₂	13.97a	11.43a	0.70a	6.47b	2.27b	1.11b	50.12a
V ₃	4.36b	2.54b	0.62b	10.79a	4.60a	1.57a	48.57b
LSD (0.05)	0.62	0.55	0.05	0.66	0.05	0.15	0.89
Days of composted sawdust							
T ₀	10.88ab	8.60a	0.68	8.37bc	3.18ab	1.59a	51.78b
T ₁	11.05ab	8.34b	0.67	8.90b	3.11bc	1.28b	45.66d
T ₂	9.17c	6.72c	0.62	10.98a	3.20a	0.99c	42.43e
T ₃	11.57a	9.21a	0.64	7.49c	3.24a	1.60a	55.00a
T ₄	10.17b	8.84a	0.63	6.07d	2.17e	1.22bc	49.39c
T ₅	10.67ab	8.46ab	0.73	6.09d	3.08c	1.17bc	51.30b
T ₆	10.56ab	7.94b	0.62	7.88bc	2.86d	1.17bc	49.14c
LSD (0.05)	0.94	0.80	-	1.02	0.08	0.23	1.36
CV (%)	9.48	10.28	10.83	10.97	2.38	15.74	2.93

In a column, means followed by a common letter are not significantly differed at 5% level by DMRT. V₁= *Pleurotus djamor*, V₂ = *Pleurotus florida*, V₃= *Pleurotus ostreatus*, T₀= 0, T₁= 5, T₂= 10, T₃= 15, T₄= 20, T₅= 25, T₆= 30

The longest stipe was found in V₃ (4.60 cm), while the shortest was in V₁ (2.06 cm). Fifteen days of composted sawdust (3.24 cm) had the longest range, which was statistically comparable to T₂ (3.20 cm). The stipe length was found to be the shortest (2.17 cm) in T₄. The stipe length varied from 5.43 cm to 1.69 cm. The longest stipe was found in V₃T₃ (5.43 cm), while the shortest stipe (1.69 cm) was found in V₁T₂. Ajonina and Tatah (2012) stated that physical quality of oyster mushroom depends on the length of stipe. Mondal *et al.* (2010) noted that the higher the stipe length, the poorer the quality of the mushrooms. Table 3 showed that the highest stipe diameter was recorded at V₃ (1.57 cm) and the lowest was obtained from V₂ (1.11 cm) which was statistically similar to V₁ (1.18 cm). Lucky (2018) reported that the stipe diameter ranged from 0.72 to 1.14 cm in different oyster mushroom species. Fifteen days of composted sawdust (1.60 cm) had the largest stipe diameter, which was statistically similar to T₀ (1.59 cm) whereas ten days had the smallest (0.99 cm) stipe. Oyetayo and Ariyo (2013) stated that mushroom cultivation was influenced by the nature of the substrates employed. The stipe with the largest diameter was found in V₃T₃ (2.35 cm) and the smallest stipe (0.61 cm) was found in V₂T₂ (Table 4). Similar results were found by Mondal *et al.* (2010) and said that the mixed substrates produced mushrooms with the highest stipe width and cap perimeter among the three substrates studied.

Biological Yield (1st flush): In terms of biological yield (1st flush), various mushroom varieties, days to composted sawdust and combination of those showed considerable variations (Table 3, 4). The maximum biological yield of mushroom (50.12 g) was obtained from V₂, and the minimum yield (48.57 g) was obtained from V₃. Fifteen days of composted sawdust (55.00 g) had the highest biological yield and ten days produced the least yield (42.43 g). The mycelia of this oyster mushroom have different colonizing potentials for the substrates in which they are grown, which ultimately corresponded to the yield obtained.

Table 4. Combined effect of variety and period of composted sawdust on yield attribute characters of oyster mushroom

Treatment	Fruiting body (No.)	Effective fruiting body (No.)	Thickness of Pileus (cm)	Diameter of Pileus (cm)	Length of Stipe (cm)	Diameter of stipe (cm)	Biological yield (1 st flush) (g)	Biological efficiency (%)
V ₁ T ₀	14.13a	11.56a	0.68abc	5.56e	2.17ij	1.24cd	50.03def	28.58def
V ₁ T ₁	14.16a	11.33a	0.69abc	8.33d	2.23hi	1.41bc	53.53bc	30.58bc
V ₁ T ₂	8.66b	6.40b	0.54cd	11.42bc	1.69k	0.83def	42.46h	24.26h
V ₁ T ₃	15.26a	12.23a	0.72ab	5.42e	2.12ij	1.25cd	55.06ab	31.74ab
V ₁ T ₄	13.96a	12.067a	0.59bc	5.26e	2.07ij	1.23cd	48.93efg	27.96efg
V ₁ T ₅	14.43a	12.06a	0.72ab	5.44e	2.11ij	1.20cde	51.13cde	29.21cde
V ₁ T ₆	13.63a	10.83a	0.57bc	5.11e	2.05j	1.13cde	49.20efg	28.11efg
V ₂ T ₀	13.83a	11.40a	0.66abc	8.05d	2.35gh	1.71b	52.93c	30.24c
V ₂ T ₁	13.90a	10.86a	0.70abc	7.53d	2.41g	0.73ef	42.13h	24.07h
V ₂ T ₂	13.96a	10.93	0.69abc	8.00d	2.63f	0.61f	46.70g	26.68g
V ₂ T ₃	14.83a	12.46a	0.81a	5.520e	2.17ij	1.21cd	56.50a	32.28a
V ₂ T ₄	13.30a	11.83a	0.64abc	5.55e	2.12ij	1.22cd	49.08efg	28.04efg
V ₂ T ₅	14.40a	11.60a	0.72ab	5.37e	2.13ij	1.14cde	50.83cdef	29.04cdef
V ₂ T ₆	13.60a	10.96a	0.66abc	5.27e	2.13ij	1.16cde	48.36fg	27.63fg
V ₃ T ₀	4.70c	2.83c	0.69abc	11.50bc	5.02c	1.82b	53.06c	30.32c
V ₃ T ₁	5.10c	2.83c	0.62bc	10.83c	4.70d	1.69b	41.16h	23.52h
V ₃ T ₂	4.90c	2.83c	0.64bc	13.53a	5.29b	1.55bc	38.13i	21.78i
V ₃ T ₃	4.63c	2.93c	0.40d	11.55bc	5.43a	2.35a	52.26cd	29.86cd
V ₃ T ₄	3.26c	2.63c	0.65abc	7.42d	2.33gh	1.22cd	50.16def	28.66def
V ₃ T ₅	3.46c	1.73c	0.74ab	7.47d	5.01c	1.17cde	51.93cd	29.67cd
V ₃ T ₆	4.46c	2.03c	0.63bc	13.27ab	4.42e	1.23cd	49.86def	28.49def
LSD	1.64	1.39	0.14	1.76	0.14	0.40	2.35	2.35
CV (%)	9.48	10.28	10.83	10.97	2.38	15.74	2.93	2.93

In a column, means followed by a common letter are not significantly differed at 5% level by DMRT. V₁= *Pleurotus djamor*, V₂= *Pleurotus florida*, V₃= *Pleurotus ostreatus*, T₀= 0, T₁= 5, T₂= 10, T₃= 15, T₄= 20, T₅= 25, T₆= 30 days

Mycelia of *Pleurotus* species are well known to colonize various lignocellulosic materials due to their extensive enzyme systems capable of utilizing complex organic compounds, which occurs in organic matter residues (Tisdale *et al.* 2006). The maximum yield (56.50 g) was produced by V₂T₃ which was statistically close to V₁T₃ (55.06 g) and the minimum yield (38.13g) was produced by V₃T₂.

Biological efficiency: Biological efficiency varied significantly due to effect of different varieties of oyster mushroom and days to composted sawdust (Figure 1) and their combination (Table 4). The maximum biological efficiency (28.64%) was obtained from V₂, and the minimum biological yield (27.75%) was obtained from V₃. Treatment T₃ produced highest biological efficiency (31.42%). The lowest biological efficiency (24.24 %) was obtained from T₂ which differed from rest of the treatments. The highest biological efficiency (32.28 %) was found in V₂T₃ which was statistically similar to V₁T₃ (31.74%). The lowest efficiency was found in V₃T₂ (21.78%).

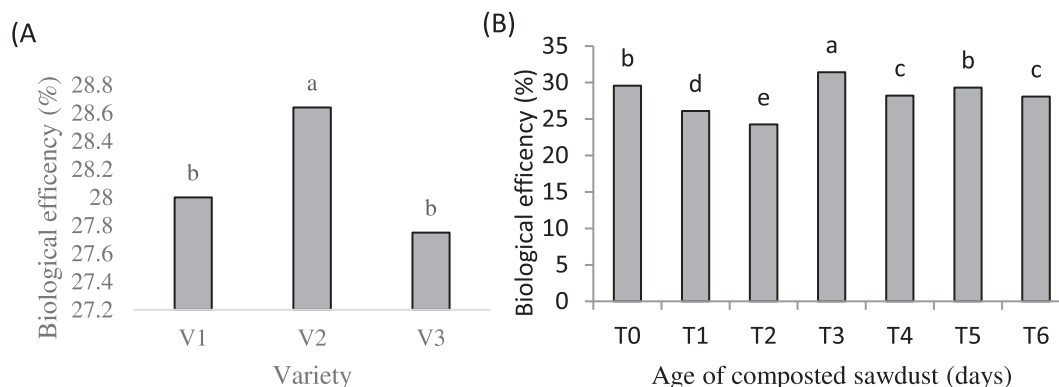


Figure 1. Effect of variety (A) and period of composted sawdust (B) on biological efficiency of oyster mushroom. Bars with common letters are not significantly differed at 5% level of significance by DMRT. V₁= *Pleurotus djamor*, V₂ = *Pleurotus florida*, V₃= *Pleurotus ostreatus*, T₀= 0, T₁= 5, T₂= 10, T₃= 15, T₄= 20, T₅= 25, T₆= 30

CONCLUSION

Based on the result, it might be concluded that *Pleurotus ostreatus* showed the best performance among the studied varieties. The 15 days composted sawdust gave the higher result among the planned treatments of the research in most cases.

REFERENCES

- Ajonina AS and Tatah LE. 2012. Growth performance and yield of oyster mushroom (*Pleurotus ostreatus*) on different substrates composition in Buea South West Cameroon. Science Journal of Biochemistry. 139:1-6.
- Bhatti MI, Jiskani MM, Waga KH, Pathan MA and Magsi MR. 2007. Growth, development and yield of oyster mushroom, (*Pleurotus ostreatus* jacq.) kummer as affected by different spawn rates. Pakistan Journal of Botany. 39(7): 2685-2692.
- Choi KW. 2004. Shelf cultivation of oyster mushroom with emphasis on substrate fermentation, In: Rick Gush (ed) Mushroom Growers Handbook 1. Part II Oyster Mushroom, Aloha Medicinals Inc., Hawaii. PP. 91-94.
- Dhanker A. 2019. Effect of compost on soil and water properties used in crop productivity. Journal of Emerging Technologies and Innovative Research. 6(1):61-64.
- Gyorfi J and Hajdu CS 2007. Casing-material experiments with *P. eryngii*. International Journal of Horticultural Science. 13(2): 33-36.
- Kinugawa K, Phusawang W, Chinbenjapho IS, Fukada S, Tanesaka E, Okada M and Tsutsui H. 1994. Progress Report (1991-1993) of joint research program of Kinkiand Chiang Mai Universities on the promotion of mushroom research. Mem Fac Agr Kinki Univ. 27: 93-113.

Nishi *et al.*/ Growing oyster mushroom on composted sawdust substrate

- Lucky HK, Akand MH and Kakon AJ. 2018. Effect of different substrates ratio on the growth and yield of oyster mushroom. Bangladesh Journal of Mushroom. 12(1&2): 23-30.
- Mohamed MF, Refaei EF, Abdalla MM and Abdelgalil SH. 2016. Fruiting bodies yield of oyster mushroom (*Pleurotus columbinus*) as affected by different portions of compost in the substrate. International journal of recycling organic waste in agriculture. 5(4): 281-288.
- Mondal SR, Rehana MJ, Noman, MS and Adhikary SK. 2010. Comparative study on growth and yield performance of oyster mushroom (*Pleurotus florida*) on different substrates. Journal of the Bangladesh Agricultural University. 8(2): 213-220.
- Moonmoon M, Uddin MN, Ahmed S, Shelly NJ and Khan MA. 2010. Cultivation of different strains of king oyster mushroom (*Pleurotus eryngii*) on sawdust and rice straw in Bangladesh. Saudi Journal of Biological Sciences. 17(4): 341-345.
- Okhuoya JA, Akpaja EO and Abbot O. 2005. Cultivation of *Lentinus squarrosulus* (Mont) Singer on sawdust of selected tropical tree species. International journal of Medicinal Mushrooms. 7(3): 440-441.
- Oyetayo VO and Ariyo OO. 2013. Antimicrobial and antioxidant properties of *Pleurotus ostreatus* (Jacq: Fries) cultivated on different tropical woody substrates. Journal of Waste Conversion Bioproducts and Biotechnology. 1(2): 28-32.
- Philippoussis A, Diamantopoulou P and Zervakis G. 2002. 'Monitoring of mycelial growth and fructification of *Lentinula edodes* on several lignocellulosic residues' Mushroom Biology and Mushroom Products. Universidad Autonoma del Estado de Morelos, Mexico. pp. 279-287.
- Sarker NC, Hossain MM, Sultana N, Mian IH, Karim AJMS and Amin SMR. 2007. Impact of different Substrates on Nutrient Content of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. Bangladesh Journal of Mushroom. 1(2): 35-38.
- Sarker NC, kakon AJ, Shamima K, Hasan MRA, Choudhuri MBKA. 2017. Effect of Different amount of substrates on growth and Yield of *Ganoderma lucidium* (GL-4) Mushroom. Bangladesh Journal of Mushroom. 11(1&2): 25-30.
- Tisdale TE, Susan C and Miyasaka-Hemmes DE. 2006. Cultivation of the oyster mushroom (*Pleurotus ostreatus*) on wood substrates in Hawaii. World Journal of Microbiology and Biotechnology. 22:201-206.
- Vetayasuporn S. 2007. The feasibility of using coconut residue as a substrate for oyster mushroom cultivation. Biotech. 6: 578-582.



EFFECT OF IRRIGATION FREQUENCY ON GROWTH AND YIELD OF SOYBEAN

B. Sinha, M. Fahmida* and M. S. Rahman

Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh

*Corresponding author: Email: maisha.fahmida@hstu.ac.bd; Cell phone: +8801737415041

DOI:<https://www.doi.org/10.59125/JST.20203>

ABSTRACT

A field experiment was conducted at the research field of HSTU, Dinajpur during November 2019 to March 2020 to find out the effect of irrigation frequency on the growth and yield of Soybean (*Glycine max* L.) cv. BARI Soybean-6. The experiment was carried out with a RCBD with four replications of irrigation treatments viz, I_0 = no irrigation (control), I_1 = one time at 20 days after sowing (DAS), I_2 = two times (20 and 40 DAS), I_3 = three times (20, 40, and 60 DAS). At 105 DAS the highest plant height (52.53 cm) was found from I_2 treatment and the shortest plant (45.82 cm) from I_0 treatment. The highest (5.91) leaf area index was obtained from the treatment of three irrigation (I_3) at 90 DAS and the lowest (5.1) leaf area index from the control (I_0). At the 90 DAS highest nodule number (9.208) and the lowest nodule number was (6.459) recorded from I_3 and I_0 , respectively. The highest (90.09 g) fresh weight was obtained from the treatment I_2 at 90 DAS and the lowest (65.64 g) was recorded in I_0 . I_3 produced the highest amount of dry matter of (29.50 g) and the lowest amount of dry matter production at harvest (20.67 g) in I_0 treatment. The highest seed yield was observed from I_2 (1.638 t ha⁻¹) which was statistically similar with I_3 whereas, the lowest obtained from I_0 (1.075 t ha⁻¹). The highest small stover yield was obtained from I_3 (1.759 t ha⁻¹) which is statistically similar to I_2 (1.754 t ha⁻¹) whereas the lowest was observed from I_0 (1.540 t ha⁻¹) which was statistically similar to I_1 (1.566 t ha⁻¹). The highest biological yield was found from I_2 (3.425 t ha⁻¹) which is statistically similar to I_3 and the lowest was obtained from I_0 (2.56 t ha⁻¹). The maximum harvest index was found from I_2 (47.71 %) and the minimum was obtained from I_0 (40.81 %). I_2 treatment showed more significant results than the other treatment I_0 , I_1 and I_3 . So, two times irrigation showed significant effect showed the highest yield of 1.638 t ha⁻¹.

Keyword: Irrigation, frequency, growth, soyabean, treatment, yield

INTRODUCTION

Soybean (*Glycine max* L.) Merrill) belongs to the family Fabaceae. It is one of the major oil seed crop as well as pulse crop of the world. Among the legume crops soybean contains the highest amount of protein and a good amount of other nutrients like calcium, phosphorus, iron, and vitamins with about 40 % proteins (Maphosa and Victoria 2016). The oil content of soybean is about 20 % while all other pulse contains about 1-2 % oil (Clemente and Cahoon 2009). It can be used as a pulse crop, can also be used for making nutritious food items like soya dal, soya khechuri, soya pollao, soya bori, soya biscuits, soya bread etc. (Mondal and Wahhab 2001). The

average seed yield of soybean at research level in Bangladesh is about 2.25 t ha⁻¹ which is comparable to the world average yield of 3.5 metric tons (FAO 2003). The crop is cultivated about 130 million hectares of land and annual production is approximately 1100 metric tons in the world (FAOSTAT 2022). Soybean is grown in almost all parts of the world for human consumption, industry and animal feed (Boydak *et al.* 2002). It is the most important grain legume of the world and a new prospective crop for Bangladesh (Rahman *et al.* 2011). Soybean seed contains 40-45 % protein, 20-22 % oil, 20-26 % carbohydrate and a high amount of Ca, P and vitamins (Rahman *et al.* 2011). Malik *et al.* (2006) depicted that soybean oil is consisted of 85% cholesterol free unsaturated fatty acids. Per hectare yield of soybean in Bangladesh is only 1.2 t (BARI 2007) as compared to other soybean producing countries of the world like USA with seed yield of 3.5 t (James *et al.* 1999). Yield of soybean may be attributed to a number of reasons, viz., unavailability of seeds of high yielding varieties with good quality, delayed sowing, fertilizer management, disease and insect infestation, improper or limited irrigation facilities, weeds and others stress condition. Water stress imposed during pre-flowering and flowering stage reduced yield of soybean by 28 % and 24 % respectively (Gunton and Evenson 1980). Similarly various soybean cultivars show varying sensitivity to drought at their different developmental stages (Momen *et al.* 1979). Hao *et al.* (2003) conducted experiments to find out effects of irrigation and found that dry matter accumulation significantly increased with irrigation application. Irrigation and variety can play important role to increase yield of soyabean. Shortening of grain filling period due to water stress (Nakasathien *et al.* 2000). Montoya *et al.* (2017) found supplemental irrigation during the reproductive stage (R1–R8) was a positive effect on soybean growth. Reduction in leaf area reduces crop growth and thus affects biomass production (Brown *et al.* 1985). The total water requirement for maximum productivity varies between 450 and 800 mm, depending on weather conditions, crop management practices and cycle timing (Embrapa 2011). Field experiment was conducted during 2016 up to 2018 to determine the optimal irrigation regime of soybean (*Glycine max* L.) at Jimma Agricultural Research center under five irrigation treatments (Irrigation at 60% ASMDL, 80% ASMDL, ASMDL, 120% ASMDL and 140% ASMDL) (Admasu *et al.* 2019). For all these, objective of this experiment was to find the effect of irrigation frequency on growth and yield of soyabean with parameters like plant height, leaf area index, nodule production, total dry matter, harvest index, stover yield and biological yield.

MATERIALS AND METHODS

A field experiment was conducted at Research Field and Laboratory at HSTU during November 2019 to March 2020. Soil characteristics of experiment site at a depth of 0-15 cm were analyzed at the Regional Laboratory of Soil Resources Development Institute (SRDI), Dinajpur. Its field duration was about 100-110 days. The soil was sandy loam. Seed yield is about 1.80-2.10 t ha⁻¹ (BARI 2011). Four irrigation treatment was designed with four replications to find its effect.

Treatments: Here, I₀ = No irrigation, I₁= One irrigation at 20 days after sowing (DAS), I₂= Two irrigation at 20 days after sowing (DAS) and 40 days after sowing DAS, I₃= Three irrigation at 20 days after sowing (DAS), 40 days after sowing (DAS) and 60 days after sowing (DAS).

The experiment was laid out in RCBD design with four irrigation replications. The size of the individual plot was 4 m × 2.5m and total numbers of plots were 16. There were 4 treatments and 4

replications combinations. Each block was divided into 4-unit plots. Layout of the experiment was done in inter plot spacing of 0.50 m and inter block spacing of 0.75 m.

Land and seedlings preparation: The land of the experimental field was first opened on November 10, 2019 with a power tiller and exposed to the sunshine for 7 days. All the fertilizers were applied at BARI recommended dose as 60 kg ha⁻¹ Urea, 175 kg ha⁻¹ TSP, 120 kg ha⁻¹ MOP, 115 kg ha⁻¹ Gypsum (BARI 2007). Seeds were treated with Vitavax-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease. Seeds were sown as per treatments of the experiment in 10 cm apart rows. The soybean plants were infested by hairy caterpillars (*Dlaerisia oblique*) and cutworm at early growth stage which was controlled by applying Sumithion 50 EC @ 1.01 ha⁻¹. Five sample plants were collected randomly from each plot.

Harvesting: The plants of central 1 m² area were harvested by placing quadrat for recording yield data. Seeds were separated from the stover by hand machine and rubbing. After proper drying of seeds to a moisture content of 12 % were kept in polythene bags. Dried seeds and stover was weighed.

Crop growth parameters

The height of plants, leaf area index, fresh weight, dry weight, number of nodules was recorded at 30, 45, 60, 75, 90 and 105 DAS. The fresh weight and dry weight of the samples was weight using a sensitive digital electric balance. Three plants were collected randomly from the inner rows of each plot and dried separately for 72 hours in an electric oven set at 60°C. All the pods of the preselected 3 sample plants in each plot were counted and averaged them to have pods plant⁻¹. One thousand sun dried cleaned seeds were counted randomly and weighted.

Yield and harvest index

Seeds obtained from harvested 1m² area of each unit plot were dried in the sun and weighed. Grain moisture content was measured by using digital moisture meter. Biological yield was calculated by using the following formula: Biological yield= Grain yield + straw yield.

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula: $HI (\%) = \frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100$

Statistical analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package program. This was used to develop an integrated microcomputer program that will assist agricultural scientists in most of the steps involved in doing agricultural research-that is to generate experimental designs, manage and transform data, and analyze experiments from both a biological and economical perspective. The significant differences among the treatment means were compared by Duncan's Multiple Range Test (DMRT) at 5 % level of probability (Gomez and Gomez 1984). It is a post hoc test to measure specific differences between pairs of means.

RESULTS AND DISCUSSIONS

Crop growth parameters (Plant height)

The significant result was found in plant height of soybean by the irrigation date at different growth stages figure 1. At 30DAS I_2 produced the taller plant (14.20 cm) and I_0 produced similar (12.34 cm). At 105 DAS I_2 produce taller plant (52.35 cm) and I_0 produce lowest plant height (45.82 cm).

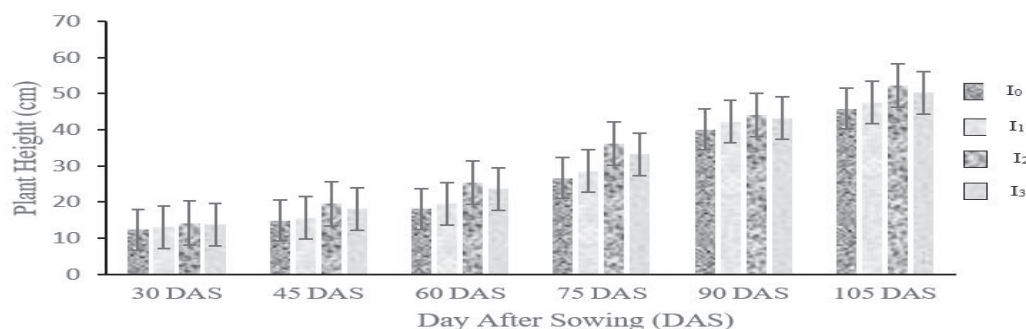


Figure 1. Effect of irrigation on plant height (cm) of soybean at different days after sowing (SE =0.3464, 0.7321, 0.8827, 1.411, 1.465 and 4.342 at 30, 45, 60, 75, 90 and 105 DAS, respectively)

Kazi *et al.* (2002) conducted an experiment to study the impact of irrigation frequencies and observed that the growth and yield components are significantly affected by irrigation frequencies. Maximum plant height and more branches per plant were found with the application of 6 irrigations followed by 5 replications, whereas, lowest number of irrigations decreased the traits adversely.

Leaf area index

Leaf area or the surface area of green leaves produced by soybean plants per unit area of land was taken as an index of leaf area development. Leaf area index were estimated measuring the length and width of leaf and multiplying by a factor of 0.75 followed. The highest (5.91) leaf area index was obtained I_3 at 90 DAS and the lowest (5.1) leaf area index was recorded from I_0 . This result agrees well with (Hao *et al.* 2003) who reported that the leaf area index significantly increased with irrigation application.

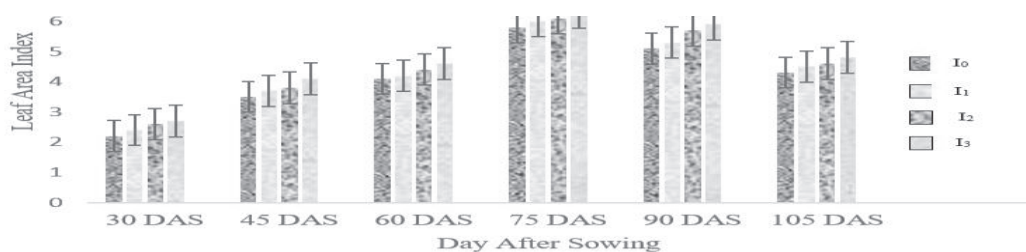


Figure 2. Effect of irrigation on leaf area index of soybean at different days after sowing (SE= 0.08175, 0.08566, 0.1032, 0.09047, 0.07350 and 0.1156 at 30,45, 60, 75, 90 and 105 DAS)

Nodule production

At the 90 DAS number of nodule is increased at the highest pick. Again, during harvest time it reduces to the starting level. In 30 DAS highest nodule number I_2 (3.41) which is statistically similar to I_3 , I_1 and lowest nodule number in I_0 (2.035). In 90 DAS nodule number I_3 (9.208) and lowest nodule number I_0 (6.459).

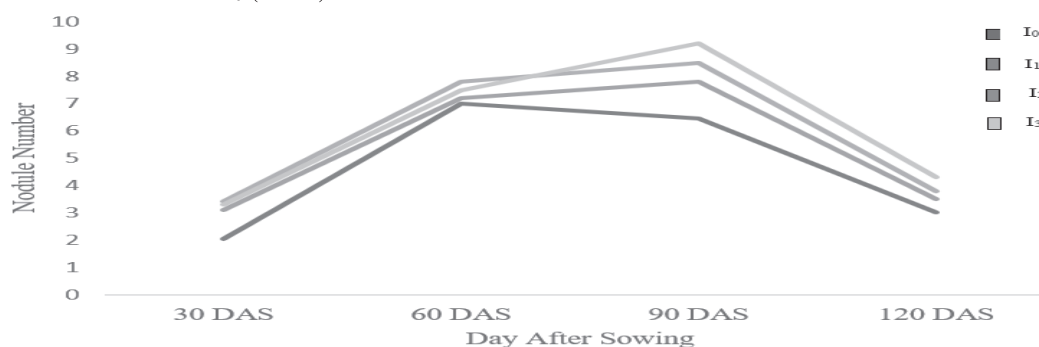


Figure 3. Effect of irrigation on nodule production of soybean at different days after sowing (SE =0.3040, 0.6936, 0.6774, 0.3277 at 30, 60, 90 and 120 DAS respectively)

Fresh weight

The fresh weight of the sample was taken using a sensitive digital electric balance. The mean weight was calculated and expressed in g plant⁻¹. Effect of irrigation method had significant influenced on the fresh weight of at different days after sowing figure 4. In 30 DAS the fresh weight was obtained same. In 60 DAS the highest value of the fresh weight got in I_3 (25.56 g). The highest (90.09 g) fresh weight was obtained from the treatment I_2 at 90 DAS and the lowest (65.64 g) fresh weight was recorded in I_0 . This result supported well with Shahidullah *et al.* (1979) who reported that the nodules number significantly increased with irrigation application.

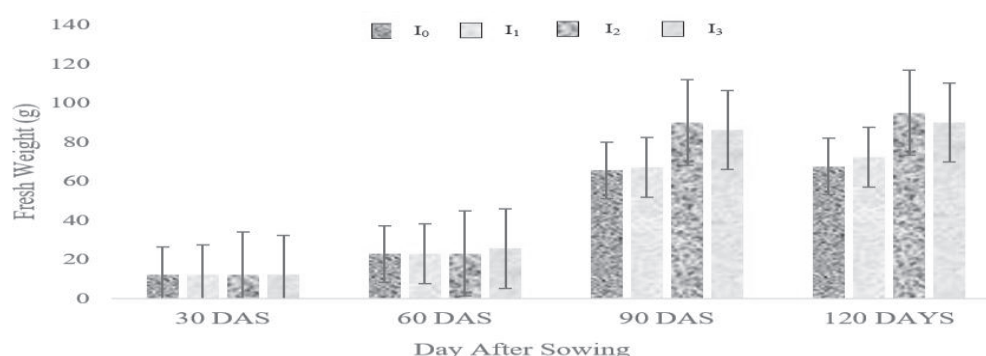


Figure 4. Effect of irrigation on fresh weight (g) of soybean at different DAS

Total dry matter production

Total dry matter production (TDM) indicates the production potentials of a crop and high at first perquisite. Figure 5 shows in 60 DAS the highest value of the dry weight got in I₃ (8.57 g) and the lowest dry weight got from I₀ (6.56 g). At 90 DAS I₃ were produced higher amount of dry matter (29.50 g) and 20.67 g in I₀ treatment.

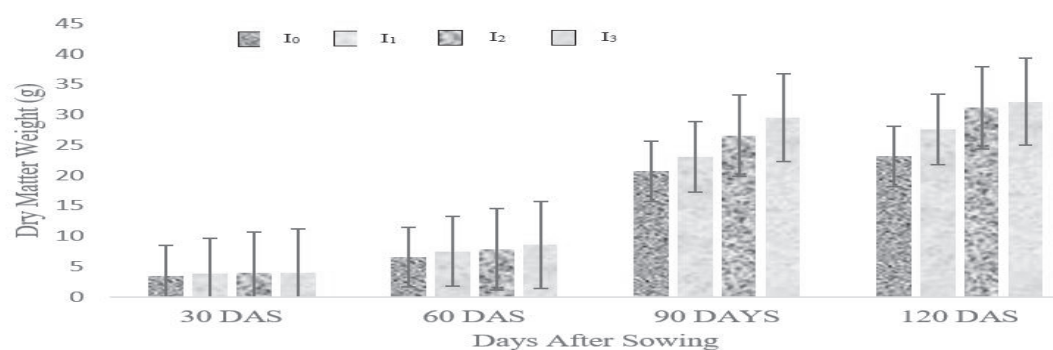


Figure 5. Effect of irrigation on total dry matter weight (g plant⁻¹) of soybean at different DAS

Yield contributing characters

The pod length varied due to irrigation shown in Figure 6 and found I₂ treatment produced longer (3.057 cm) pod. The highest number of filled pod plant⁻¹ (20.67) was observed from I₃ and the lowest was found in I₀ (12.83). Kazi *et al.* (2002) conducted an experiment to study the impact of irrigation frequencies and observed that the Filled Pods Plant⁻¹ significantly affected by irrigation frequencies. The maximum number of seed pod⁻¹ (32.30) was found from I₃ and the minimum number of seed plant⁻¹ (15.75) at I₀. Hao *et al.* (2003) conducted experiments and found that increased with irrigation application. The maximum 1000 seed weight (103.9 g) was found from I₃ and the minimum 1000 seed weight (99.69 g) was produced from I₀. Mean separation was done using LSD at 5% probability level.

Table 1. Effect of irrigation on yield contributing characters of soybean

Treatment	Filled Pods Plant ⁻¹	Length of Pod	No. of Seed Pod ⁻¹	1000-seed weight (g)
I ₀	12.83 b	3.027 a	15.75 c	99.69 b
I ₁	13.87 b	3.032 a	18.50 b	102.5 a
I ₂	19.98 a	3.057 a	31.87 a	102.8 a
I ₃	20.67 a	3.045 a	32.30 a	103.9 a
LSD	1.078	0.1045	1.856	1.535
CV%	43.78	21.46	45.38	12.20

Mean with the same letter are not statically significant, LSD = least significant difference, CV= Coefficient of Variation

Yield and harvesting index

The maximum yield of soybean (1.638 t ha^{-1}) was from I_2 and the minimum yield of soybean (1.075 t ha^{-1}) was produced from I_0 . Kazi *et al.* (2002) also reported that the maximum seed yield was found superior with the application of 3 irrigations followed by 2 irrigations, whereas, the lowest number of irrigations decreased all the traits adversely. Constable and Heam (1984) found irrigations during late flowering and pod filling in soybean was necessary to ensure maximum seed yield (up to 305 t ha^{-1}).

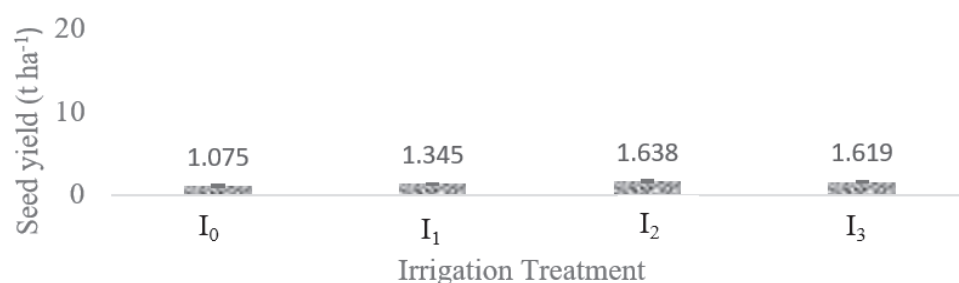


Figure 6. Effect of irrigation on seed yield (t ha^{-1}) of soybean at different days after sowing

Stover yield

The highest Stover yield was obtained from I_3 (1.759 t ha^{-1}) which is similar to I_2 (1.754 t ha^{-1}) whereas the lowest was observed from I_0 (1.540 t ha^{-1}) and I_1 (1.566 t ha^{-1}). Norwal and Malik (1986) found that stover yield significantly increased with irrigation.

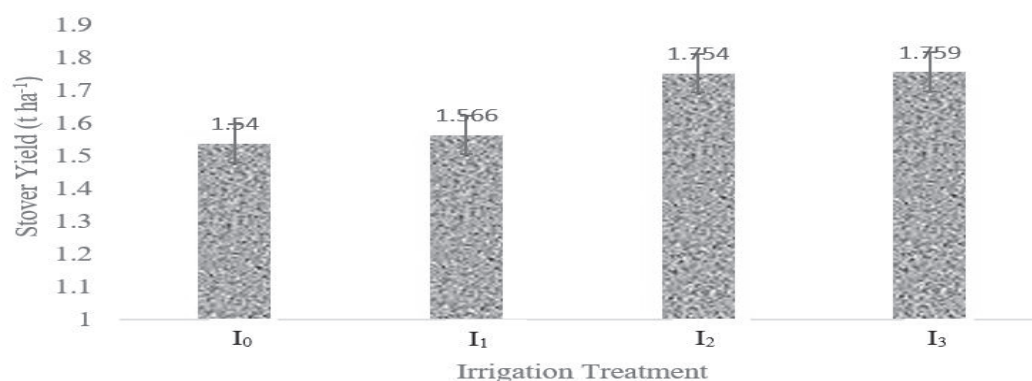


Figure 7. Effect of irrigation on Stover yield (t ha^{-1}) at different days after sowing

Biological yield

Irrigation frequency had significant effect on biological yield. The highest biological yield was found from I_2 (3.425 t ha^{-1}) which is statistically similar to I_3 and the lowest was obtained from I_0 (2.56 t ha^{-1}). Shahidullah *et al.* (1979) who reported that biological yield significantly increased with optimum irrigation frequency.

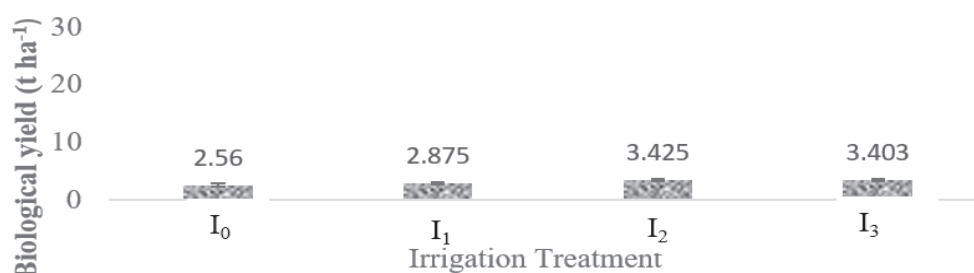


Figure 8. Effect of irrigation on biological yield (t ha^{-1}) of soybean at different days after sowing

Harvest index

Irrigation shows significant effect on harvest index. Numerically the highest harvest index was observed from I_2 (47.71 %) which is statistically similar to I_3 and minimum was found in I_0 (40.81 %).

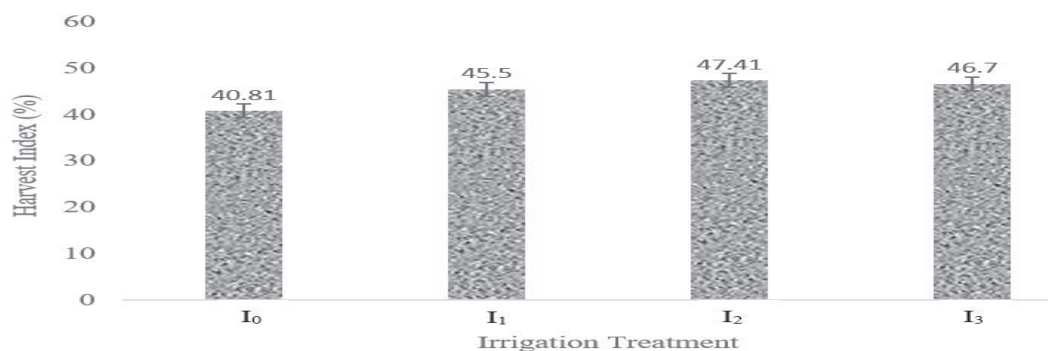


Figure 9. Effect of irrigation on harvest index (%) of soybean at different days after sowing

CONCLUSION

The experiment was carried out with a split plot design with four replications of irrigation treatments. Data were analyzed using MSTAT-C computerized package program. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance. From the overall result, the tallest plant and highest fresh weight was obtained from I_2 treatment. The highest leaf area index, higher amount of dry matter and height nodule number was obtained from I_3 at 90 DAS. Results showed that the highest seed yield was

Sinha *et al.*/ Effect of irrigation frequency on growth and yield of soybean

observed from I₂ and lowest was in I₀ treatment. From the obtained result, there is a significant difference among treatments on soybean grain yield and water productivity. water scarcity is the most critical constraint for the development of agriculture in arid and semi-arid climates. Hence, effective use of available water with appropriate irrigation scheduling has a significant implication on irrigated agriculture and overall crop production.

REFERENCES

- Admasu R Asefa A and Tadessa M. 2019. Determination of optimal irrigation scheduling for soybean (*Glycine max* L.) yield and water productivity at Jimma, South West Ethiopia. *Journal of Agricultural Resources & Technology*. 19(4): 556101-556115.
- BARI (Bangladesh Agriculture research Institute). 2007. Krishi Projukti Hatboi (in Bangla. 7st Edition) Bangladesh Agriculture Research Institute, Gazipur, Bangladesh. pp.163.
- BARI (Bangladesh Agriculture research Institute). 2011. Krishi Projukti Hatboi (in Bangla. 10th Edition) Bangladesh Agriculture Research Institute, Gazipur, Bangladesh. pp. 159.
- Boydak E, Alpaslan M, Hayta M, Gercek S and Simsek S. 2002. Seed composition of soybeans grown in the harran region of Turkey as affected by row spacing and irrigation. *Journal of Agricultural Food Chemistry*. 50: 4718-4720.
- Brown ED and Caviness C. 1985. Response of selected soybean cultivars to soil moisture deficit. *Journal of Agronomy*. 77(2): 274-278.
- Clemente TE and Cahoon EB. 2009. Soybean Oil: Genetic Approaches for Modification of Functionality and Total Content. *Journal of Plant Physiology*. 151(3):1030-1040.
- Chowdhury MMU, Farhad ISM, Bhowall SK, Bhowmik SK and Chowdhury AK. 2014. Fertilizer management for maximizing soybean (*Glycine max* L) production in char lands of Bangladesh. *Bangladesh Agronomy Journal*. 22(1): 89-93.
- Constable GA and Heam AB. 1984. Irrigation for crops in a sub- humid environment. *Journal of Irrigation Science*. 5(7):75-94.
- Embrapa. 2011. Exigências Climáticas. In: Tecnologia de produção de soja - Região central do Brasil. *Journal of Londrina*. pp.11-12.
- FAO (Food and Agricultural Organization). 2003. Statistic division. Sudan. pp.344.
- FAOSTAT (Food and Agriculture Organization of the United Nations). 2022. Production- crops: Roma, Food and Agriculture Organization of The United Nations.URL <http://faostat.fao.org/site/567/default.aspx#ancor>. (Accessed on 05/08/2022)
- Gomez and Gomez. 1984. Duncan's Multiple Range Test (With Diagram) for Statistical Analysis for Yield. pp. 25.
- Guntan JL and Evenson JP. 1980. Moisture stress in navy beans and effect of withholding irrigation at different phenological stages on growth and yield. *Journal of Irrigation Science*. 2: 49-58.
- Hao L, Sun CS, Lei SX and Liu LJ. 2003. Coupling effect of water and fertilizer on soybean yield and nutrient absorption. *Journal of Northeast Agricultural University*. 10 (2): 105-114.
- James WJ, Shrikant SJ and Kenneth JB. 1999. Climate change: Implication for soybean and yield and management in the USA. *Proceedings of University of Florida, Florida, USA*. pp.150-155.

- Kazi BR, Oad FC and Lakho A. 2002. Effect of irrigation frequencies on growth and yield of soybean. *Pakistan Journal of Applied Sciences*. 2(6): 661-662.
- Malik MFA, Qureshi AS, Ashraf M and Ghafoor A. 2006. Genetic variability of the main yield related characters in soybean. *International Journal of Agriculture and Biology*. 8(6): 815-819.
- Maphosa Y and Victoria AJ. 2016. The Role of Legumes in Human Nutrition. *Proceedings of Human Behavior*. pp.101.
- Momen, NN, Carlson RE, Shaw RH and Arjmand O. 1979. Effects of moisture stress on yield components of two soybean cultivars. *Journal of Agronomy*. 71(1): 86-90.
- Mondal MRI and Wahhab MA. 2001. Effects of variety, inoculum and Phosphorus on the performance of soybean. *Pakistan Journal of Biological Science*. 7(12):2072-2077.
- Montoya F, Garcia C, Otero A and Pintos F. 2017. Effect of irrigation regime on the growth and yield of irrigated soybean in temperate humid climate condition. *Journal of Agricultural Waste Management*. 193:30-45.
- Nakasathien S, Israel W, Wilson F and Kwanyuen P. 2000. Regulation of seed protein concentration in soybean by supra-optimal nitrogen supply. *Journal of Crop Sciences*. 40: 1277-1284.
- Norwal and Malik. 1986. Growth and yield of soybean with Irrigation Effect. *Journal of Agricultural Management*. 19: 112.
- Rahman MM, Hossain MM, Anwar MP and Juraimi AS. 2011. Plant density influence on yield and nutritional quality of soybean seed. *Asian Journal of Plant Sciences*. 10(2): 125-132.
- Shahidullah M, Rahman MA and Hossain M. 1979. Effect of time of sowing and variety on the growth and yield of soybean. *Bangladesh Journal of Biological Science*. 8(1): 49-54.
- Sweeney DW, Long JH, and Kirkham MB. 2003. A single irrigation to improve early maturing soybean yield and quality. *Soil Science Society of America Journal*. 67 (1): 2350- 2357.



EFFECT OF SMOKING AS POST-HARVEST TREATMENT ON THE RIPENING AND QUALITY OF BANANA (*Musa sp*)

M. H. Rahman^{1*}, M. T. Aktar¹, M. A. Kabir¹, M. H. Rahman¹ and M. T. Abedin²

¹Department of Horticulture, ²Department of Biochemistry and Molecular Biology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh.

*Corresponding author: E-mail: hassan@hstu.ac.bd; Cell Phone: +8801719468999

DOI:<https://www.doi.org/10.59125/JST.20204>

ABSTRACT

The application of smoke is a traditional practice to trigger the ripening process of banana. This experiment was conducted to investigate the effects of different post-harvest treatment on the physiochemical properties of banana fruits. This experiment was laid out in a Completely Randomized Design (CRD) with three replications, which constituted the seven treatments *viz.* control, low density polyethylene bag, as well as 12, 18, 24, 30 and 36 hours exposed to smoke. The results indicated that smoke treatment increased physiological weight loss and pulp weight during storage whereas decreased firmness, peel weight and dry matter content. Chemical parameters such as moisture, total soluble solid, and total sugar showed an increasing trend during the storage period, whereas acidity and vitamin C increased initially up to 5 days and declined thereafter during the ripening of the banana. Smoking for 18 hours resulted in uniform ripening with yellow coloration within 5 days, whereas untreated control fruits remained green for 5 days and ripened within 8 days after storage. The present study concludes that smoke treatment is a simple but quick means of banana ripening. Exposer of banana fruits to smoke for 18 hours produced better quality and improved the shelf life.

Keywords: Banana, ethylene, fruit ripening, shelf life, sugar

INTRODUCTION

Banana (*Musa sp.*) is an important fruit all over the world due to its auspicious flavor, nutritious value and medicinal properties. After rice, wheat and maize, it ranks as the fourth-most significant staple food in the world. Banana ranked top on the list of fruits in Bangladesh, with an annual production of 826.15 thousand MT from 49.45 thousand ha of land (BBS 2021). It is the only fruit crop that is available around the year and the most-consumed fruit than any other fruit. The banana fruit is perishable and a significant portion of it is spoiled. After harvest, the fruit undergoes significant physiological changes that contribute to its perishability (Momen *et al.* 1993). Normally bananas are harvested at a mature stage and fruits are not generally allowed to ripen on the plant. After harvesting, fruits need a few days to ripen naturally. Fruits' skin cracks, ripens unevenly and doesn't develop a pleasing color or aroma when they ripen naturally, which lowers their marketability (Khader *et al.* 1990). To solve this problem, people frequently utilize harmful artificial substances such as ethanol, glycol, calcium carbide, acetylene, ethylene, propylene, 2-chloroethyl phosphonic acid, and ethrel, which can lead to major health issues like heart disease,

skin illness, lung failure, and kidney failure (Siddiqui and Dhua 2010). In many developing countries inexpensive traditional and biological methods such as smoking and keeping with hay and banana leaves are practiced (Gomasta and Mondoal 2016). Generally, people in Bangladesh use smoking from burning rice husks, wood litter, etc. to ripen banana. Due to the presence of both acetylene and ethylene in the smoke, it is commonly accepted that this practice accelerates the ripening of banana (Saranada 1990). However, most people are unaware of how smoking affects fruit quality and how it varies over time. Poor exterior color development and uneven ripening are both caused by improper smoke treatment (Kulkarni *et al.* 2011). However, a few studies have been carried out on evaluating the effects of different durations of smoking on the quality of banana. Therefore, the present study was conducted to evaluate the effects of different duration of smoking treatments on the physio-chemical properties of banana fruits.

MATERIALS AND METHODS

Fruit materials and treatments: Banana (*Musa* Sp.) cv. Amritsagar were collected at mature green stage from the research field near Hajee Mohammad Danesh Science and technology University (HSTU), Dinajpur and immediately moved to the laboratory of the department of Horticulture, HSTU. Healthy fruit with uniform size and shape were selected, washed in clean water and then air dried. The experiment was set in Completely Randomized Design (CRD) with three replications. The seven treatments were as follows; T₀= control, T₁= fruit covered with low density polyethylene (LDPE) bag, T₂= 12 hours, T₃= 18 hours, T₄= 24 hours, T₅= 30 hours and T₆= 36 hours exposed to smoke. The traditional earthen chambers were used for ripening. Rice husk was burnt in the outer combustion unit next to the chamber. Through the pipes, the smoke was brought into the chamber's lower section. After treatment, the samples were placed in plastic crates at ambient conditions. To measure the physical and chemical parameters ten fruits were arbitrarily chosen for each treatment and replication at 2, 5 and 8 days after storage.

Data collection

Physical parameters: The pulp and peel weight were recorded by using a monoplan electronic balance and expressed in gram (g). Physiological weight loss was estimated using the following formula: Percent weight loss=Initial weight (g)-Final Weight(g)/Initial weight(g) ×100. With the help of a pressure tester by using a 5/16 plunger, firmness of fruits was determined and expressed in kg cm⁻². Moisture and dry matter content was determined according to AOAC (1980).

Peel color change: Daily peel color change were recorded at storage and ripening stage by using standard banana ripening chart of Dadzie (1997). The standard banana ripening chart consists of 7 color plates. Where: 1 = green; 2 = green with yellow tracks; 3 = more green than yellow; 4 =more yellow than green; 5 = yellow with green tips; 6 = all yellow, and 7 = yellow flecked with black spots.

Chemical parameters: Using the Erma Hand Refractometer (0–32° Brix), total soluble solids were calculated and represented in Brix. The method of Ranganna (1997) was used to measure titratable acidity, total sugar, and vitamin C.

Ripening period and shelf life: Based on the variations in color and firmness of the bananas, the ripening period was calculated. The number of days till the fruit reached its fully mature stage was noted (Color stage 4). After ripening, the shelf life (days) was recorded. When the fruits began to spoil, the fruits had reached the end of its shelf life.

Statistical analysis: The experimental data were analyzed using IBM SPSS statistics 22 program. The significant differences between the treatment means were calculated using Tukey's test. Statement of statistically significant differences between the experimental treatments at the probability level of $P \leq 0.05$.

RESULT AND DISCUSSION

Physical characteristics: The different smoking treatments significantly influenced the fruit physiological weight loss (PWL), pulp and peel weight, dry matter, firmness and color (Table 1 and 2). Physiological weight loss (PWL) of banana fruits gradually increased with the advancement of storage period. The highest PWL (5.61%) was measured on 8th days in 36 hours smoking treated fruits whereas the minimum PWL (5.31%) was observed at low density polyethylene (LDPE) covered fruit. Some external and internal factors i.e., temperature, relative humidity and peel permeability regulate the rate of PWL (Duan *et al.* 2007). An upsurge in PWL in bananas could be due to increase temperature by smoking treatment (Abraham *et al.* 2021). The result of this study indicated a continuous rise in pulp weight during the storage period. At 8th days after storage (DAS) the pulp weight was increased by 41.75% due to application of 18 hours smoking comparing to control. Oppositely, the peel weight of LDPE covered fruit and 18 hours smoke treated fruits decreased from 49.35 to 49.03 and from 25.06 to 24.91 g, respectively after 8 DAS. Whereas in control fruits, the peel weight decreased from 35.84 to 35.06 g after 8 DAS. The weight of pulp increased than peel because of the transpiration rate of peel was higher than pulp. Similar results were reported by previous author who found a higher pulp to peel ratio in bananas ripened with smoking (Mebratie *et al.* 2015). Also, on the storage time the dry matter content gradually decreased (Table 2). The dry matter content was reduced by 4.42% in fruits exposed to 36 hrs smoking at 8 DAS compared to the untreated control. The early softening of smoke treated fruit might be cause of enhanced ripening. The loss of firmness was higher in 36 hours smoking (3.13 to 0.25 kg cm⁻²) and the untreated fruits were found to be highly firm during storage (3.56 to 2.50 kg cm⁻²). These outcomes were also consistent with banana (Mebrati *et al.* 2015).

Table 1. Effect of smoking treatments on physiological weight loss (PWL), weight of pulp and weight of peel on banana at different storage time

Treatments	Storage time (day)								
	PWL (%)			Weight of pulp (g)			Weight of peel (g)		
	2	5	8	2	5	8	2	5	8
T ₀	1.17c	4.21a	5.31c	93.09g	94.65g	94.36g	35.84c	35.95c	35.36c
T ₁	1.53a	4.55a	5.29c	142.4c	144.1c	143.3c	49.35a	49.61a	49.03a
T ₂	1.50ab	4.26a	5.35bc	124.2d	124.8d	124.9d	40.25b	40.26b	39.33b
T ₃	1.16c	4.56a	5.36bc	158.3a	162.0a	162.0a	25.06e	25.03e	24.91e
T ₄	1.22bc	4.26a	5.43b	113.2e	116.4e	116.4e	25.28e	25.28e	24.60e
T ₅	1.30abc	4.36a	5.59a	104.7f	104.5f	103.1f	27.87d	28.25d	28.29d
T ₆	1.16c	4.22a	5.61a	151.6b	154.6b	154.3b	28.50d	28.55d	27.99d
LSD	0.28	1.55	0.07	4.28	5.84	5.28	1.56	1.61	1.16
CV %	12.25	20.09	3.85	1.90	2.55	2.31	2.65	2.72	1.99

Means followed by same letter(s) within each column didn't significantly different (Tukey's test, $p \leq 0.05$). T₀= Control, T₁= Low density polyethylene bag, T₂= 12, T₃= 18, T₄= 24, T₅= 30 and T₆= 36 hours smoking.

Fruit color was increased with the storage period of banana. Color development was faster with the smoking treatment as compared to control. The highest color score (7.00) attained at 36-, 30- and 24-hours smoking treatment at 8 DAS. The lowest value (4.00) was found in control and

LDPE treatment at 8 DAS. It was probably due to the higher amount of ethylene production from smoking. There is an interconnection between and ethylene and chromoplast development at the ripening stage which is occurred due to the carotenoid pathway being under positive control of ethylene (Klee and Giovannoni, 2011). Smoking likely produces more ethylene when it is burned, which accounts for the quicker coloration that has been observed (Mebratie *et al.* 2015).

Table 2. Effect of smoking treatments on dry matter, firmness, and color on banana at different storage time

Treatments	Storage time (day)								
	Dry matter (%)			Firmness (kg/cm ²)			Color		
	2	5	8	2	5	8	2	5	8
T ₀	29.47a	29.87a	27.80a	3.56a	3.37a	2.50a	1.00 c	2.00 d	4.00 c
T ₁	29.11a	28.31bc	27.62a	3.35a	3.24a	1.41b	1.00 c	3.00 c	4.00 c
T ₂	30.17a	28.72b	27.80a	3.50a	2.44b	1.02c	2.00 b	4.00 b	6.00 b
T ₃	30.14a	28.29bc	27.26ab	3.19a	0.56d	0.31d	2.00 fb	4.00 b	6.00 b
T ₄	30.48a	28.77b	26.72b	3.30a	0.95c	0.32d	3.00 a	5.00 a	7.00 a
T ₅	30.10a	28.12bc	26.97ab	3.37a	0.46d	0.34d	3.00 a	5.00 a	7.00 a
T ₆	30.29a	27.48c	26.57b	3.13a	0.43d	0.25d	3.00 a	5.00 a	7.00 a
LSD	1.35	0.80	0.81	0.49	0.21	0.11	0.7	0.58	0.21
CV %	2.54	1.59	1.68	8.37	7.56	7.16	20.03	8.22	2.02

Means followed by same letter(s) within each column didn't significantly different (Tukey's test, $p \leq 0.05$). T₀= Control, T₁= Low density polyethylene bag, T₂= 12, T₃= 18, T₄= 24, T₅= 30 and T₆= 36 hours smoking.

Quality characteristics: The moisture content, total soluble solid (TSS), acidity, vitamin C and total sugar of banana fruit was significantly influenced by using different smoking treatments (Figure 1). The moisture content of smoking treated fruits gradually increased during storage and reached a maximum of 73.43% in 36 hr smoking treatment at 8 DAS. Control fruits showed minimum moisture content of 72.2% on 8 DAS. Moisture content of fruit increased due to an upsurge in sugar content resulting in starch hydrolysis to sugar (Mohapatra *et al.* 2010). The TSS content of fruits significantly increased with storage period (Figure 1). The TSS in all smoke fruits showed higher value than the control fruit. The highest TSS content (22.17%) was recorded in 18 hr and lowest (12.37%) were recorded in control at 8 DAS. Due to an increase in water soluble sugar content brought on by the starch hydrolysis, pulp moisture content increased. The conversion of starch into water soluble sugars could be the attribute cause of raising TSS during storage (Dadzie 1997). Titratable acidity increased from the initial value in all the treatment reaching a peak and declining later during the ripening process. The titratable acidity increased by 69% in 18 hours smoking at 5 DAS compared to control. The decrease in acidity later during ripening may be due to use of organic acid in respiratory process (Mahajan *et al.* 2010). Vitamin C content of fruits decreased in banana fruit during storage. Control fruit showed highest ascorbic acid degradation from 6.48 to 5.05 mg/100g whereas 18 hours smoking treated fruit displayed lowest degradation from 8.47 to 7.2 mg/100g. Due to the oxidation of ascorbic acid in ripened fruit, the amount of vitamin C decreased. According to the chemistry of ripening, vitamin C levels drop as temperatures rise (Njoku *et al.* 2011). In this study, the total sugar of treated and controlled bananas increased gradually. Highest total sugar content 27.67% was recorded in T₃ and lowest 12.15% was recorded in control at 7 DAS. The total sugar was increased by 53.68% and 56.09% in 18 hr smoking at 5 and 8 days, respectively over the control. Due to the conversion

Rahman *et al.*/ Ripening response of banana to smoking

of complex starch to simple sucrose such as glucose and fructose by the enzymatic activities as well as the conversion of polysaccharides to soluble solids, the initial rise of total sugar content increased and reduction of total sugar due to its utilization in respiration process. The results were in conformity with the Subbaiah *et al.* (2014).

Ripening period and Shelf life: There were significant differences of ripening period and shelf life by using different types of smoking treatment (Figure 2). The shortest ripening period (3 days) was observed in 36 hours smoking whereas the highest ripening period (8 days) was observed in control. The fruit treated with smoke ripened quickly due to the influence of exogenous ethylene and the high temperature produced by smoking, which may boost the physico-chemical changes (Mebratie *et al.* 2015). Shelf life was improved by 25% upon exposure of 18 hours smoking in comparison to the untreated control (natural ripening). The findings of the current experiment were confirmed by Mebratie *et al.* (2015).

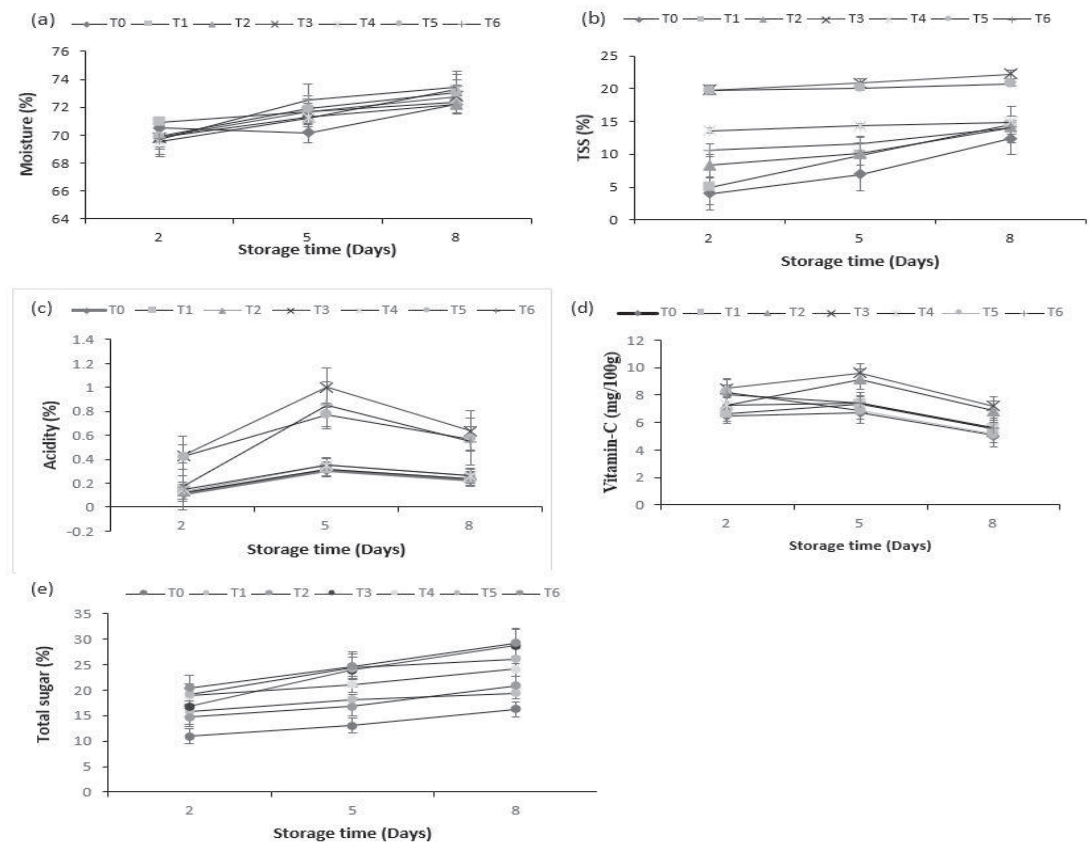


Figure 1. Effect of smoking treatments on (a) moisture, (b) TSS, (c) acidity, (d) vitamin-C and (e) total sugar on banana at different storage time. Vertical bar indicates LSD at 5% level of significance. T₀= Control, T₁= Low density polyethylene bag, T₂= 12, T₃= 18, T₄= 24, T₅= 30 and T₆= 36 hours smoking.

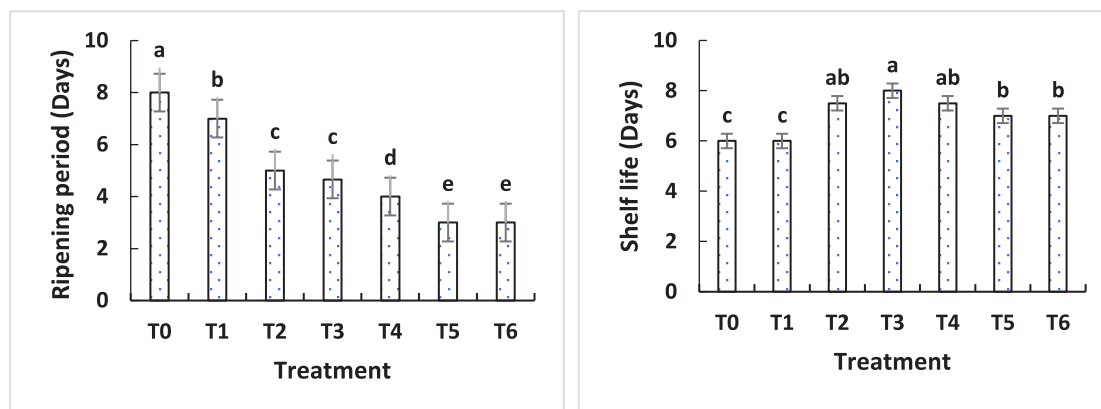


Figure 2. Effect of smoking treatments on ripening period and shelf life on banana at different storage time. Vertical bar indicates LSD at 5% level of significance. T₀= Control, T₁= Low density polyethylene bag, T₂= 12, T₃= 18, T₄= 24, T₅= 30 and T₆= 36 hours smoking.

CONCLUSION

From the present study it could be concluded that the fruits treated with smoking for 18 hours ensure faster and uniform ripening under ambient conditions after 5 DAS compared to control (8 days). The ripening stage, the smoking for 18 hours treated banana fruits improved physio-chemical properties such as PWL, softness, TSS and total sugar (%) compared to non-treated fruits. The consequence of the study of safe ripening agents benefits for health and is also commercially beneficial to traders due to early availability and less post-harvest loss.

ACKNOWLEDGEMENT

We are grateful to Ministry of Science and Technology, Government of the Peoples' Republic of Bangladesh for funding this research work (Grant No. ES-392, Year 2021-2022).

REFERENCES

- Abraham BM, Saleh BK and Zelelew DZ. 2022. Effect of post-harvest handling and ripening methods on quality and shelf-life of Banana. American Journal of Plant Sciences. 13:175-192.
- AOAC. 1980. Official Methods of Analysis. Association of Official Analytical Chemists (12th Edition) Washington, D. C. pp. 376-384.
- BBS. 2021. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Statistics Division, Ministry of Planning, Government of the Peoples Republic of Bangladesh. pp. 210.
- Dadzie BK. 1997. Post-harvest characteristics of black sigatoka resistant banana, cooking banana and plantain hybrids. INIBAP Technical Guidelines, Vol. 2. pp. 1-75.
- Duan X, Joyce DC and Jiang Y. 2007. Post-harvest biology and handling of banana fruit. fresh produce. 1: 140-152.

Rahman *et al.*/ Ripening response of banana to smoking

- Gomasta J and Mondal DMF. 2016. Artificial ripening of banana by application of heat. *European Academic Research*. 4(6): 5915-5931.
- Khader A, Chellappan K, Chattopadhyay PK and Anchanam Alagia Pillai O. 1990. Banana. In: *Fruits Tropical and Subtropical*. Naya Prokash, Calcutta. pp132-185.
- Klee HJ and Giovannoni JJ. 2011. Genetics and control of Tomato fruit ripening and quality attributes. *Annual Review of Genetics*. 45: 41-59.
- Kulkarni SG, Kudachikar VB and Prakash MNK. 2011. Studies on physico-chemical changes during artificial, ripening of banana (*Musa* spp.) variety “Robusta”. *Journal of food Science and Technology*. 48(6): 730–734.
- Mahajan BVC, Tajendra K, Gill MLS, Dhaliwal HS, Ghuman BS and Chalil BS. 2010. Studies on optimization of ripening techniques for banana. *Journal of food Science and Technology*. 47(3): 315-319.
- Mebratie MA, Weldetsadik K, Ayalewand A and Haji J. 2015. Comparative Study of Different Banana Ripening Methods. *Science, Technology and Arts Research Journal*. 4: 32-38.
- Mohapatra D, Sabayasachi M and Namrata S. 2010. Banana and its by-products utilization: an overview. *Journal of Science and Industrial Research*. 69: 323-329.
- Momen MN, Rahim MA, Farooque AM and Choudhury MSH. 1993. Effect of some coating materials and physical measures on the prolongation of shelf life of banana. *Progressive Agriculture*. 4(1-2):41-51.
- Njoku PC, Ayuk AA and Okoye CV. 2011. Temperature effects on vitamin C content in citrus fruits. *Pakistan Journal of Nutrition*. 10(12): 1168–1169.
- Ranganna S. 1997. *Hand book of Analysis and Quality control for fruit and vegetable Products* (2nd ed.). New Delhi, India: Tata-Mc. Graw-Hill Publishing Company Ltd. Pp. 11-12.
- Sarananda KH. 1990. Effect of calcium carbide on ripening of ‘Embul’ Banana (*Musa* spp.). tropical agriculturist. Horticulture division, Getambe, Peradeniya, Sri Lanka. Pp.146.
- Siddiqui MW and Dhua RS. 2010. Eating artificial ripened fruits is harmful. *Current Science*. 99(12):1664–1668.
- Subbaiah KV, Jagadeesh SL, Manjula R and Kumar YL. 2014. Effect of ethrel dip and smoke treatments on the ripening behavior of banana fruits cv. Grand Naine. *Research Journal of Agricultural Sciences*. 5(6):1294-1298.



**PERFORMANCE STUDY OF A WALKING TYPE 4-ROW MECHANICAL RICE
TRANSPLANTER**

M. Fahmida*, U. Habiba, M. S. Rahman and Milufarzana

Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and
Technology University, Dinajpur, Bangladesh

*Corresponding author: Email: maisha.fahmida@hstu.ac.bd; Cell phone: +8801737415041

DOI: <https://www.doi.org/10.59125/JST.20205>

ABSTRACT

A study was carried out at Bangladesh Rice Research Institute, Regional Station, Rangpur along with laboratory test and farmers field in Fulgachi, Lalmonirhat for field test during Aman season with BRRI dhan52 to identify the effect of plant spacing of transplanter on grain yield. Three levels of plant spacing (30 cm×13 cm, 30 cm×15 cm, 30 cm×17 cm), seedling density setting (Middle, Middle+1 and Middle+2) and RCBD with 9 plots were used for the purpose. In field experiment, three plant spacing and Middle+2 seedling density setting was used. In this walking type self-propelled rice transplanter, the field capacity, field efficiency and fuel consumption of the transplanter were 0.134 ha hr⁻¹, 68 % and 3.71 L ha⁻¹, respectively. Labor requirement for mechanical and manual transplanting were 6.75 man ha/hr and 223 men hour per hectare respectively. Cost of mechanical transplanting was Tk. 3291 per hectare as compared to Tk.13000 per hectare in case of manual transplanting. If the usage of this machine per year decreases, the operating cost per hectare will increase. From breakeven analysis with mechanical and manual operating cost, it was found that transplanter should use at least 11 hectares per year to minimize the operation cost per hectare. For 17 cm, 15 cm and 13 cm plant spacing, number of tray requirement were 218, 270 and 277 per hectare, respectively. Number of seedling tray saved for 17 cm and 15 cm spacing were 21 % and 2.53 % compared with 13 cm spacing. In 30 cm×17 cm spacing, minimum number of seedlings required maximum no. of tray saved. Grain yield in different spacing (30 cm×13 cm, 30 cm ×15 cm, 30 cm ×17 cm) and manual transplanting were 4.43, 4.97, 5.23, 4.13 t ha⁻¹, respectively. Results showed that, highest grain yield among plant spacing was found 5.23 t ha⁻¹ from 30 cm×17 cm.

Keywords: Plant spacing, grain yield, rice transplanter, tray seedlings, walking type, economic feasibility

INTRODUCTION

Rice (*Oryza Sativa*) is the staple food for a large portion of the world's population including Bangladesh. Rice is the staple food of about 166.3 million people of Bangladesh (BBS 2022). It provides nearly 48 % of rural employment, 61.83 % percent of her population lives in the villages and agriculture is the major occupation of the people (BBS 2022). Total irrigated area under different crops in the country is about 55,56,614 hectares (64.72 % of net cultivation) of which

transplanted rice (Aus, Aman, and Boro) area is about 462,268 hectares (BBS 2022) and total area, production and per hectare yield of rice is 10.5 million hectares, 25 million tons and 2.87 tons/ha, respectively (BRKB 2020). Rice covers most of the cropping area in Bangladesh which is mostly a labor-intensive crop and requires hardship through a small, low-cost transplanter can be a best solution to this problem (Rahaman *et al.* 2022). Singh *et al.* (1985) reported that transplanting takes about 250–300 man-hours per hectare which is roughly 25 % of the total labor requirement of the crop. Traditional rice transplanting caused several health problems to labors such as backache, skin disease etc. (BRRI 2013). In case of transplanting at 2.5 cm water level, maximum yield was obtained primarily due to highest number of hills per sq. meter, followed by increased number of productive tillers per plant and number of fertile grains per panicle (Saleem *et al.* 2015). Marumkar *et al.* (2014) examined 10 different village in Kharif season with self-propelled four row MAHINDRA Model and found field capacity, field efficiency and fuel consumption 0.1 ha h⁻¹, 65 % and 10 L ha⁻¹, respectively and mechanical cost Rs 1500 ha⁻¹ as compared to Rs 5000 ha⁻¹ for manual transplanting in India. Karthik *et al.* (2018) and Manjunatha *et al.* (2009) also satisfied with transplanter for cultivating 28-hectare field with minimum labor. Saha *et al.* (2021) reviewed Divulging technical skill, confirming timely accessibility and boosting custom hiring may be some of the practical solutions. Islam *et al.* (2016) found the growing cost for mat type seedling for mechanical transplanter was 53 % and traditional seedbed was 34 % and mechanical transplanting reduced 1.8 percent input cost than hand transplanting in crop cultivation. Hossen *et al.* (2018) evaluated Walking type (Model-DP480) and riding type (S3-680) rice transplanter in different locations for 2011-2013. Hossen *et al.* (2022) evaluated multiple field problems and tried to find out solutions to make transplanters more user-friendly and cost-effective in Bangladesh. Transplanting may also allow crop intensification as the crop is in the main field for minimum time (IRRI 2003). Bangura *et al.* (2018) designed a transplanter fitted with seedlings number counting device. By mechanical rice transplanters, transplanting can be done in accurate spacing in rows and no need of additional land for seedling preparation. Alogaidi *et al.* (2009) were reported that plant spacing of 20 cm × 20 cm was better than those of 15 cm × 15 cm under normal soil for rice productivity. Munna *et al.* (2014) conducted a study with Kukje transplanter and found field efficiency and planting efficiency of the transplanter were 83.33 % and 95 %, respectively. Shaikh *et al.* (2021) were conducted an experiment at three different locations during the dry season (Boro) to determine the best seeding density and found 150-160 g per tray was suitable. Total number of lands are decreasing due to urbanization and mans' are towards the town creating labor and experienced manpower scarcity. Main objective of the study was to evaluate the performance of Korean DP-480 four row type rice transplanters in respect of spacing, adjustment of seedling density setting to optimize number of seedlings, to estimate the fuel consumption and field capacity of transplanter and to estimate the break-even point of transplanter.

MATERIALS AND METHODOLOGY

Specification of Transplanter: Machine specification was: Made in Korea; Engine Model DP-480; Engine hp 3(1.5kw); Type of Machine: Mechanically operated, Field Capacity: 1.5 bigha per hr; Fuel: Petrol, Tray requirement: 4, No. of seedling per hill: 2 to 7, No of picker: 4, Workability: 33 acres (From Machine manual).



Figure 1. Mechanical rice transplanter (Model DP-480) and Seedlings tray with mate.

Location and duration: The experiment site was located at the regional station, BRRI, Rangpur for laboratory test and for field test at fulgachi, Lalmonirhat during aman season (June to November, 2019). Soil of the field was sandy clay loam soil, low in organic matter content and its general low fertility level and under sub-tropical climate that was characterized by high temperature. Seeds of BRRI dhan52 were collected from the BRRI office, Rangpur.

Experimental design and treatments

Mechanically operated tray type test along with RCBD design replicated on nine plots.

For laboratory test: Space setting: $T_1 = 13$ cm; $T_2 = 15$ cm; $T_3 = 17$ cm;

Seedling density setting: Middle; Middle + 1; Middle + 2;

For field test: Space setting: $T_1=13$ cm; $T_2=15$ cm; $T_3=17$ cm; Seedling density setting: Middle+2.

Preparation of plot and seeds for sowing: Seeds were immersed in water with bucket for 24 hours and then kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours. Calculation for the germination percentage by the following formula,
$$\text{Germination(\%)} = \frac{\text{Number seeds germinated}}{\text{Number seeds on tray}} \times 100$$

A piece of high land was selected in the Regional Station, BRRI, Rangpur for raising seedlings. The experiment was laid out in a randomized complete block design (RCBD). The size of the individual plot was 10 m × 6.5 m and total numbers of plots were 9. Then the sprouted seeds were sown in the nursery bed. For mechanical Transplanter, seedlings were grown in a tray which size 58 cm × 29 cm.

Land preparation: For aman season, the age of seedling of tray must be range at 13 to 18 days. The prepared land was 2.5 cm water depth to avoid floating of seedling and 11 cm puddling depth. For manual and Mechanical transplanting land preparation was remain same. The transplanter was operated by running length wise with 3 spacing and setting seedling density with Middle, Middle+1, Middle+2. For field test, Middle+2 density was used. The number of seedling number per hill, number of missed hills, hill to hill distance was noted.

Preparation for mechanical rice transplanter: At first carefully fulfilled 4 chamber of rice transplanter with 4 tray seedlings. Observations on speed of operation, depth of placement of seedlings, time taken for turning, time taken for loading of seedling mat on to the transplanter, total time taken for transplanting, total area covered, width of coverage and quantity of fuel

consumed for the operation were recorded. Using the above information, the following parameters were computed for mechanical transplanter:

Theoretical field capacity: Theoretical field capacity, $C_{th} = \frac{SW}{10}$ ha hr⁻¹, Where, C_{th} = Field efficiency, %; S= forward speed, (km h⁻¹); W=width of equipment (m).

Actual field capacity: Actual field capacity, $C_{eff} = \frac{A}{T}$ ha hr⁻¹, where, C_{eff} = Actual field capacity, (ha hr⁻¹); A= total area, (ha); T=Total time, (hr).

Field efficiency: Field efficiency = $\frac{C_{eff}}{C_{th}} \times 100$, Where, C_{eff} = Actual field capacity, (ha hr⁻¹); C_{th} = Theoretical field capacity, (ha hr⁻¹).

Cost of mechanical transplanting: Cost of mechanical transplanting per hectare was worked out after taking into consideration the fixed cost, labor cost, fuel cost, field capacity of the equipment and usage of the equipment in terms of hectares per year and was compared with the manual transplanting.

Regulation of irrigation: The flood irrigation was applied in field to maintain a constant level of standing water up to 6 cm in early stage to enhance tillering and 10 to 12 cm in later stage to discourage late tillering. 48 days after transplanting, transplantations water management is the most complicated variable in System of Rice intensification (SRI) technique. The rice roots were not allowed to grow in a hypoxic, anaerobic condition caused by continuous flooding and saturated soil. Starting from panicle initiation, a thin layer of water (2 to 3 cm) was kept on the plots.

Data collections: Observations were regularly made and the field looked nice with normal green plants. From each unit plot 10 m² area (excluding Border hills) was selected randomly. Threshing was done by pedal thresher. The panicles were threshed, grains were dried and processed and the yield was recorded after adjusting its moisture content to 14% by using the following formula:

$$\% \text{ Moisture content} = \frac{(\text{Fresh weight} - \text{Oven dry weight})}{\text{Fresh weight}} \times 100$$

$$\text{So adjusted yield at 14\% moisture content} = \frac{(100 - \% MC)}{86} \times W, \text{ Where, } W = \text{Fresh weight of grain.}$$

Statistical analysis: Statistical analysis was done by using software Statistix 9.0. Least significant difference was used to compare the means.

Cost calculation for fuel and labor

$$\text{Fuel, } F \text{ (Tk/ha)} = \frac{\text{Fuel consumed (lit/day)} \times \text{price (Tk/lit)}}{\text{Area covered (ha/day)}} \text{ and}$$

$$\text{Labor, } L \text{ (Tk/ha)} = \frac{\text{Sum of wages of laborers (Tk/day)}}{\text{Area covered (ha/day)}}$$

RESULTS AND DISCUSSION

Spacing adjustment in laboratory test

In mechanical transplanter, line to line spacing in machine was fixed at 30 cm whereas, plant to plant spacing was varied. Plant to plant spacing was set 13, 15 and 17 cm. In figure 2, effect of spacing (13 cm) at seedling density setting “Middle” position was shown in 1st figure. Maximum percentage of seedling density was found at 14–16 cm and maximum spacing was found in 73 % when plant to plant spacing was set in 13 cm Spacing. Due to slippage 3 % spacing were found

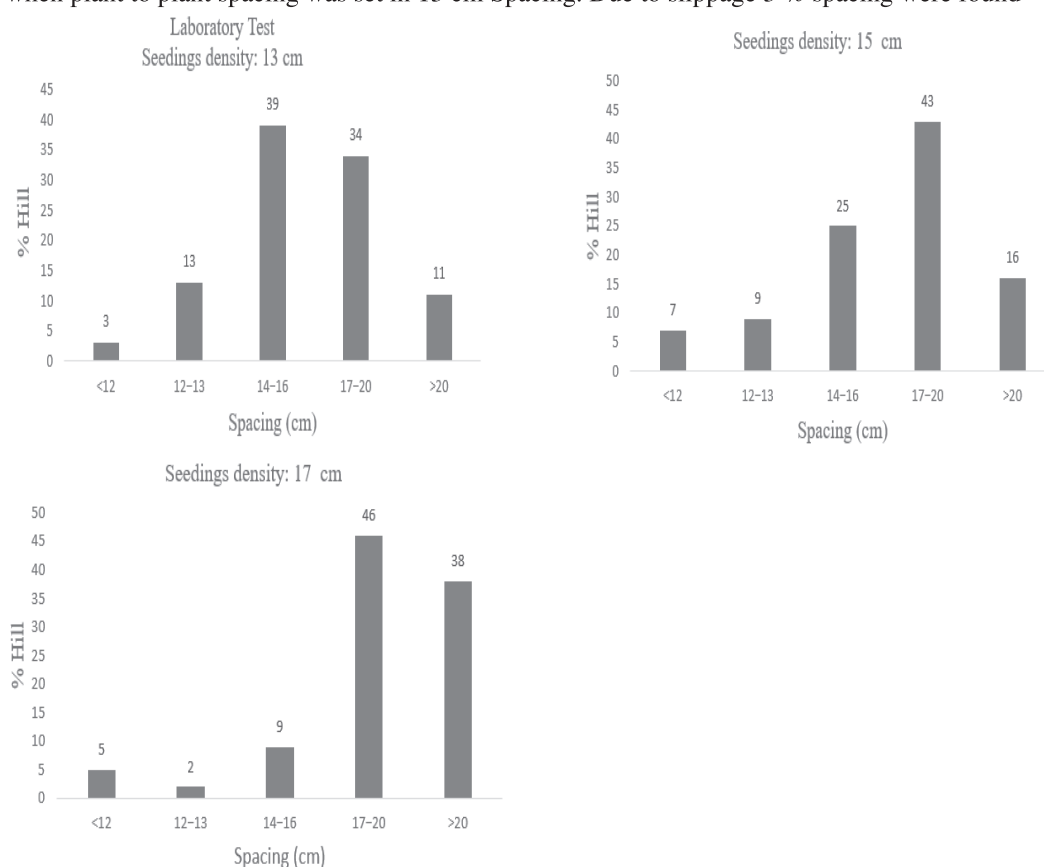


Figure 2. Effect of plant to plant spacing 13, 15 and 17 cm on seedling density setting “Middle” position, “Middle+1” and “Middle+2” position under laboratory condition.

and 84 % spacing were found for skidding. 2nd figure showed the effect on plant spacing 15 cm at seedling density setting “Middle+1” position. Plant to plant spacing obtained within 18-19 cm and maximum spacing found in 68 %. Due to slippage, 7 % spacing were found and 84 % spacing were found for skidding. In 3rd figure, the effect of 17 cm at seedling density setting “Middle+2” position was shown and maximum 84 % was found at 19-20 cm or greater than 21 cm spacing. Due to slippage 5 % spacing were found and 93 % spacing were found for skidding test.

Seedling density adjustment in laboratory test

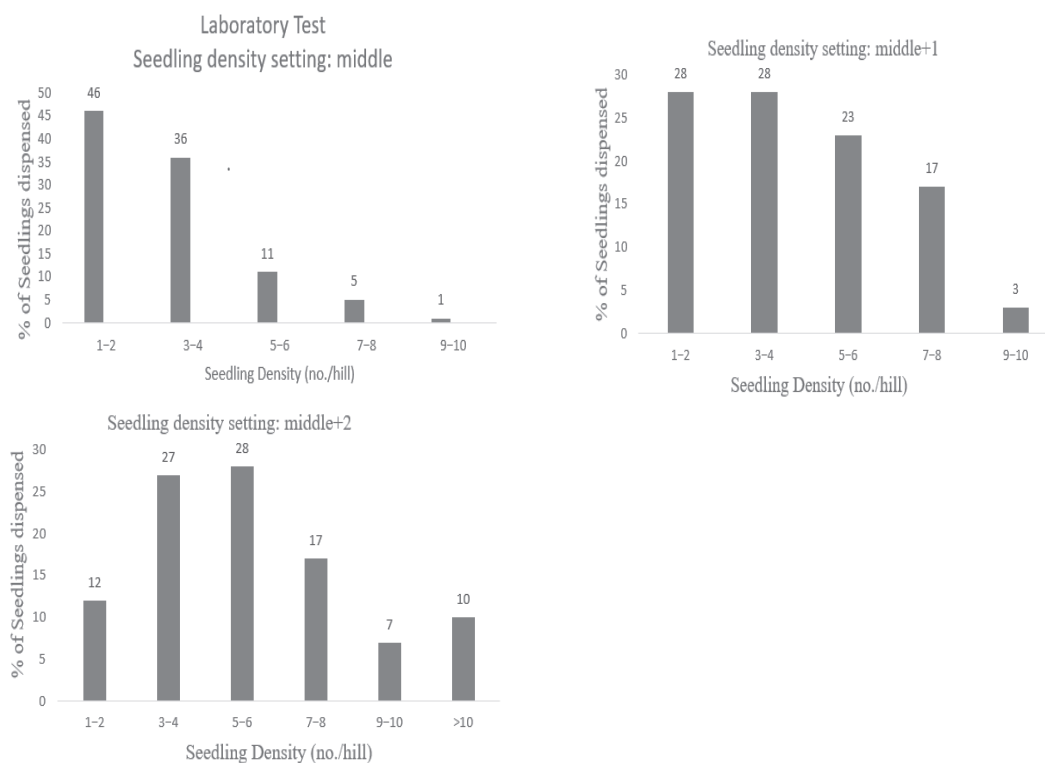


Figure 3. Effect of number of seedlings dispensed on seedling density (no./hill) at density setting “Middle”, “Middle+1” and “Middle+2” position for 13, 15 and 17 cm plant spacing under laboratory condition.

In figure 3, 1st figure explained the effect of seedlings dispense on seedling density (no./hill) setting at “Middle” position in 13 cm plant to plant spacing showing minimum (1-4) number of seedlings dispensed in 82 % hills. More than 5 number of seedlings dispensed in 17 % hills. In 2nd figure, effect on seedling density setting “Middle+1” position in 15 cm spacing was shown. Minimum (1-4) number of seedlings dispensed per hill was 56 % and maximum dispensed in 43 %. Effect on seedling density setting “Middle+2” position in 17 cm spacing was shown in 3rd figure. Seedlings dispensed per hill which was 39 % and maximum seedling dispensed per hill obtained (5-6).

Spacing adjustment under field test

In practical situation, most of the place’s plant to plant spacing was not consistent and sometimes higher and lower than 17 cm. Effect of plant spacing (13 cm) at seedling density setting “Middle+2” position was shown in 1st figure in figure 4, where maximum areas covered at 12-16 cm spacing. Maximum spacing was found in 67 %. Due to slippage, 6 % spacing were found and 55 % spacing were found for skidding. Again, in 2nd figure, effect on spacing (15 cm) at seedling

Fahmida *et al.*/ performance of a walking type 4-row rice transplanter

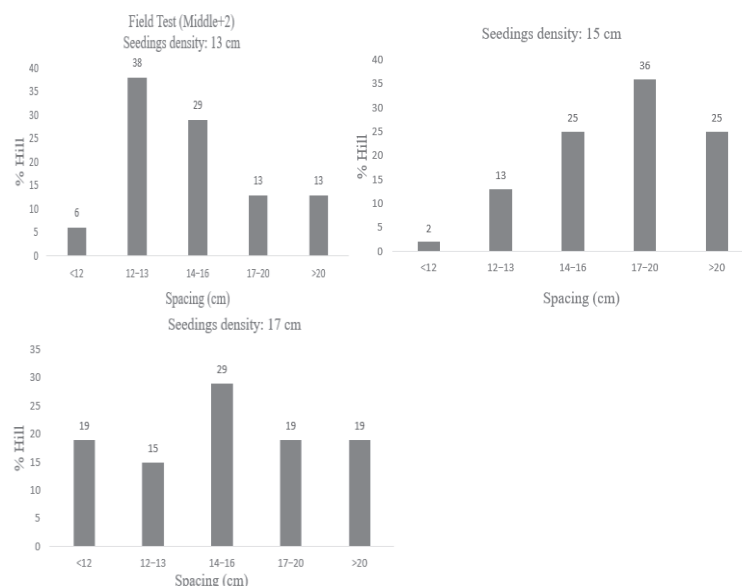


Figure 4. Effect of plant spacing 13, 15 and 17 cm at seedling density setting “Middle+2” position under field condition. density setting “Middle+2” position was showed and maximum area covered at 16-19 cm spacing or greater than 19 cm spacing almost 25 %. Maximum spacing was found in 86 %. Due to slippage, 2 % spacing were found in less than 14 cm and 86 % spacing were found for skidding. Effect of spacing (17 cm) at seedling density setting “Middle+2” position under field was shown in 3rd figure 4. 29 % maximum spacing was found and 38 % spacing were found for skidding and 34 % spacing due to slippage.

Seedling density adjustment in field test

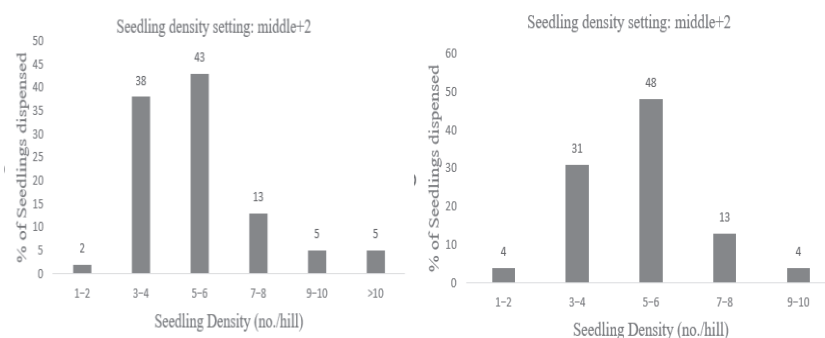


Figure 5. Effect of number of seedlings dispensed on seedling density (no./hill) at seedling density setting “Middle+2” position for 13, 15 and 17 cm spacing under field test.

1st figure, effect of seedlings dispensed on seedling density no./hill at “Middle+2” position in 15 cm spacing was shown. Minimum (1-4) number of seedlings dispensed per hill which was 38 % and maximum (5-6) number of seedlings dispersed per hill was 42 %. Effect on seedling density setting in 13 cm spacing (2nd figure) showed that minimum (1-4) number of seedlings dispensed per hill which was 40%. Maximum (5-6) number of seedlings dispensed per hill which was 43%. It depends on seedling emergence and germination percentage of seeding. In 3rd figure, effect on seedling density setting in 17 cm spacing was shown. Minimum (1-4) number of seedlings dispensed per hill was 35% and maximum (5-6) number 48%.

Table 1. Comparative inputs for mechanical transplanting and traditional transplanting

Parameter	Mechanical transplanting	Manual transplanting
Variety	BRRI dhan52	BRRI dhan52
Seed rate	12.5 kg dry seed/ha	37.5 kg/ha
Seedling raising technique	Plastic tray method	Traditional seedbed
Age of seedling	14 days	25 days
Soil type	Sandy clay loam soil	Sandy clay loam soil
Plant height	16.60 cm	30 cm
Depth of placement	4.8 cm	5.5 cm
Row to row distance	30 cm	30 cm
Plant to plant distance	13 cm, 15 cm, 17 cm	13 cm, 15 cm, 17 cm

Table 2. Yield and yield contribution character

Location	Treatment	Grain yield, t ha ⁻¹	Panical no./m ²	Panical length, cm	Grain no./m ²
Rangpur	Mechanical transplanting	4.43 a	237.53 a	21.20 a	21512 b
Lalmonirhat	Manual transplanting	4.13 b	222.57 b	20.33 b	25350 a
CV, %		6.25	16.22	5.57	15.25
LSD _{0.05}	L	0.22	38.05	1.05	3063
	T	0.22	NS	1.05	NS

Seeding tray requirement

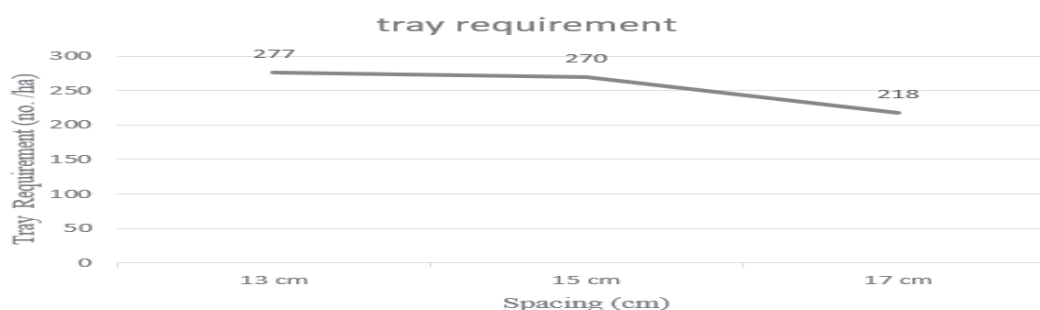


Figure 6. Effect of spacing on required tray, number per hectare.

Fahmida *et al.*/ performance of a walking type 4-row rice transplanter

Seedling tray requirement depend on plant-to-plant space setting. Figure 6 showed that seedling tray requirement decreases with the increase in plant-to-plant space setting. Tray requirement for 17 cm, 15 cm and 13cm spacing were 218, 270 and 277 no./ha, respectively. At least 21 percent seedling tray can be saved for space setting 17 cm which reduced the cost of seed and seedling tray preparation.

Effect of plant spacing on yield performance of mechanically transplanted rice

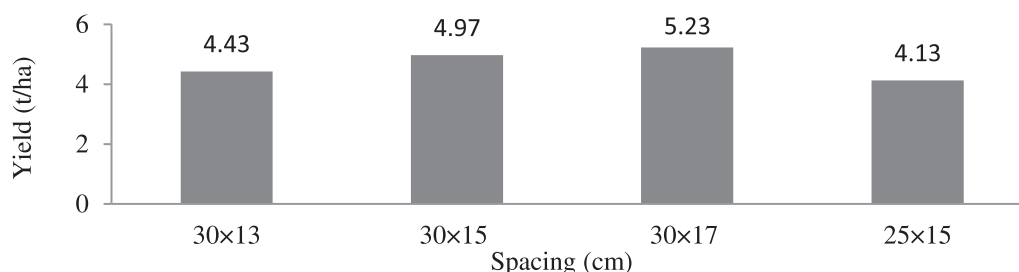


Figure 7. Effect of plant spacing on yield performance compared with manual transplanting.

The average yield of three plot for mechanical transplanting was 5.23 t/ha, 4.97 t/ha, 4.43 t/ha at 17 cm, 15 cm, 13 cm, respectively and for manual transplanting 4.13 t/ha. Maximum yield obtained at 17 cm spacing compared with other spacing. Pest attacked in closer spacing (13 cm) plot due to lack of good aeration and light interception. The yield performance of BRRI dhan52 was more in mechanically transplanted rice compared to manual transplanting.

Labor requirement: Labor requirement for mechanical rice transplanting obtained in 6.75 hour per hectare. For manual transplanting obtained in 223 man-hour per hectare which was less in mechanical transplanting.

Fuel consumption: Fuel consumption of walking type mechanical transplanter obtained 3.71 liter per hectare.

Field capacity: Field capacity of mechanical transplanter obtained 0.134 hectare per hour.

Break even analysis

Break even analysis of transplanter (figure 7) means that the mechanical rice transplanter should be operated on at least 1ha per year to produce break even outcome with neither loss nor profit

with 13000 Tk./ha yearly

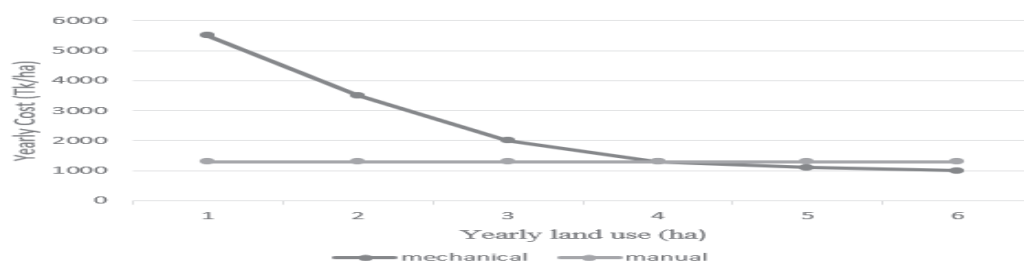


Figure 7. Break even analysis for mechanical and manual transplanting

CONCLUSION

Rice transplanter is a new technology in Bangladesh which is not adopted yet due to various machine limitations like pricing, seedlings preparation, tray availability, lack of skilled manpower, etc. 17 cm spacing was found most economical for this rice transplanter model. In Bangladesh, rice is the main cereal crop and almost 90% done with hand broadcasting which takes lots of time and manpower. Due to rapid industrialization, manpower is decreasing day by day. So its high time to adopt these new technologies to overcome existing and upcoming problems.

REFERENCES

- Alogaidi FF, Al-Shugeairy, Hadi BH and Hassan WA. 2019. Effect of planting distance on yield and yield components of four introduced upland rice varieties under aerobic conditions. *Journal of Plant Archives*. 19(1): 699-607.
- Bangura A, Zouxi Z and Jongjun J. 2018. Research on rice transplanter fitted with seedlings number counting device. *Journal of IFAC Papers On Lines*. 51(17):256-261.
- BBS. 2020. Yearbook of Agricultural Statistics 2019: Bangladesh Bureau of Statistics, Statistical and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka. Bangladesh. pp. 360.
- BRKB. 2020. Bangladesh rice Knowledge Bank, Bangladesh Rice Research Institute, Gazipur, Dhaka, Bangladesh. pp. 99.
- BRRI. 2013. Bangladesh Rice Research Institute. Gazipur, Dhaka, Bangladesh.
- Hossen MA, Huda MD, Jaman MK and Aktar S. 2018. Validation of walking and riding type rice transplanter in different location of Bangladesh. *Eco-friendly Agricultural journal*. 11(4):43-59.
- Hossen MA, Shahriyar MA, Isalm S, Paul H and Rahman MM. 2022. Rice Transplanting Mechanization in Bangladesh: Way to Make It Sustainable. *Journal of Agricultural Science*. 13(2):249-259.
- IRRI. 2003. International Rice Research Institute. pp. 313.

Fahmida *et al.*/ performance of a walking type 4-row rice transplanter

- Islam AKMS, Rahman MA, Rahman AKML, Islam MT and Rahman MI. 2016. Techno-economic performance of 4-row self-propelled mechanical rice transplanter at farmers field in Bangladesh. *Journal of progressive Agriculture*. 27(3):369-382.
- Karthik G, Srinivas I, Adake VR, Edukondalu L and Jha A. 2018. Development and performance evaluation of manually operated two row paddy transplanters. *The Andhra Agricultural Journal*. 65(special):69-76.
- Manjunatha MV, Reddy MBG, Shashidhar SD and Joshi VR. 2009. Studies on the performance of self-propelled rice transplanter and its effect on crop yield. *Karnataka Journal of Agricultural Science*. 22(2): 385-387.
- Munnaf MA, Hossain MM and Ruma FY. 2014. Techno-economic performance of imported kukje self-propelled rice transplanter. *Journal of Bangladesh Agricultural University*. 12(1):161-166.
- Murumkar RP, Dongarwar UR, Phad DS, Borkar BY and Pisalkar PS. 2014. Performance testing of four row self-propelled paddy transplanter. *International Journal of Science, Environment and technology*. 3(6):2015-2019.
- Paul S, Hossen MA, Nath BC, Rahman MA and Hosen S. 2016. Effect of soil setting period on performance of rice transplanter. *Journal of Scientific Research*. 12: 14-20.
- Rahaman H, Rahman MM, Islam AKMS, Huda MD and Kumruzzaman M. 2022. Mechanical rice transplanting in Bangladesh: current situation, technical challenges, and future approach. *Journal of Scientific Research*. 13: 130-149.
- Saha R, Patra PS and Ahmed AS. 2021. Impact of mechanical transplanting on rice productivity and profitability-review. *International Journal of Economic Plants*. 8(4):226-230.
- Saleem MS, Akthar M, Farooq U, Iqbal N and Haider Z. 2015. Effect of different water depths on plant population and rice (*Oryza sativa*) yield at time of transplanting using mechanized transplanter. *International Journal of Scientific & Engineering Research*. pp.6(6).
- Shaikh NY, Alam MA, Kamruzzaman M, Mamun MAA and Islam AKMS. 2021. Effect of seeding density on Mat-type seedling quality for mechanical transplanting in dry season rice. *Journal of Agricultural Science*. 12(11):1231-1243.
- Singh G, Sharma TR and Bockhop CW. 1985. Field performance evaluation of a manual rice transplanter. *Journal of Agricultural Engineering Research*. 32(3):259-268



**DESIGN DEVELOPMENT AND PERFORMANCE EVALUATION OF SOLAR
POWERED SPRAYER WITH WATER LEVEL INDICATOR**

S. Banu*, Milufarzana, M. M. Haque, M. S. Islam and S. R. Roy

Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and
Technology University, Dinajpur, Bangladesh

***Correspondence author:** E-mail: selina.nit@gmail.com; Cell phone: 01740229643

DOI:<https://www.doi.org/10.59125/JST.20206>

ABSTRACT

Currently in Bangladesh farmers use hand operated sprayer or motorized sprayer in agricultural fields. Generally in the agricultural field, traditional or conventional techniques like shoulder mounted spraying system have been used because it is cheaper, easy to use and less costly. Continuous use of traditional energy resources will have high risk of rising in price and energy depletion. Now-a-days there is a great need for “conservation of energy” and application of renewable energy. This paper presents the design, development and evaluation of a solar powered spraying system. The specific objectives of this research is to design and fabricate the solar powered sprayer by considering parameters like desired spraying rate, low weight, low cost, faster coverage of area and high field efficiency. A two-nozzle sprayer was fabricated with MS bar frame and 4-wheel trolley with water level indicator which runs on power source as a DC battery (12 volt, 8.2 Ah) via solar panel and runs by a DC motor (12 volt, 2A). The entire unit is portable and is operated by one labor. The design mainly eliminates the shoulder mounting sprayer setup which causes back pain, uses of fossil power which is non-renewable and hazardous and extensive use of manpower. The machine was compared to conventional sprayer and found more efficient. Pump efficiency almost 83.33% found for single nozzle and 93.33% for double nozzle and the sprayer is 58% time saving than manual sprayer. The operating cost of the machine was 802 Tk ha⁻¹. Also found capital recovery factor, capital consumption and annual cost of the solar operated sprayer were 0.26, Tk 1520 and Tk 41665, respectively.

Keyword: Sprayer, water level indicator, machine performance, field efficiency, solar panel

INTRODUCTION

Modern Agricultural Mechanization is developing day by day. In present years, solar energy has given more attention for generating power, as a clean and renewable energy source. According to world energy report, we get around 80% of our energy from conventional fossil fuels like oil (36%), natural gas (21%) and coal (23%) (Krishnappa *et al.* 2017). Renewable energy can be utilized in many applications, like for lighting and heating in performing different agricultural devices. One of the most important agricultural devices is sprayer. Sprayer is the device which

converts the mechanical energy into hydraulic energy. Spraying is the disposition of small amounts of water or liquid particles of effective size and distributing them uniformly over the surface area. Sprayer provides optimum utilization of pesticides, herbicides or any other liquid with minimum effort (Mishra *et al.* 2019). In a solar powered sprayer solar energy is first used to charge a storage battery and stored in the battery. Than the battery is used as power source to run the mechanical portion of the sprayer. Solar sprayer are very cost effective at the locations where spraying is required (Mukesh *et al.* 2018). The aim of this research work that the user need not carry the spraying instruments on his shoulders but just pull the mechanism mounted on the trolley to operate the pump and spray the pesticides. This makes the user feel comfortable, relaxed and less tiresome. The high pressure sprayers are often called as hydraulic sprayers (Siddharth *et al.* 2016). The sun powered cell contain semi-conductor material which utilize the photovoltaic impacts. At that point when the daylight is opposite to exterior of the PV sun powered board, could acquire higher efficient system. This research deals with efficient solar powered automated controlling spraying machine, to increase productivity of crops, to save time of farmers and avoid pollution problems. This machine would decrease the operational cost and decrease labor cost by using the advancing method. So solar powered spraying system can be a new concept to water on the horticultural crops, small plants and gardening purpose. The specific objectives were (i) to design and develop the solar powered hydraulic sprayer, record effective output voltage from solar panel and calculate efficiency of the sprayer and (ii) to measure the flow rate, pressure of the pump, evaluate the application rate on the field and study performance.

MATERIALS AND METHODS

The solar powered sprayer was made by locally available low cost materials procured from the local market. Frame structure of the sprayer was designed in AIE lab, HSTU, Dinajpur and fabricated in Shamim Engineering Workshop, Kalitola, Dinajpur.

Major components: The main components of solar powered hydraulic sprayer were used as follows: Solar panel, solar controller, DC battery, DC motor with pump, bucket with lid, hose pipe, trigger, lance, spray nozzle, pressure gauge, trolley wheel and water level indicator which is shown in Figure 1. Specification of solar power, solar controller, DC battery and DC motor with pump are shown in Table 1.

Table 1. Specifications of solar panel, solar controller, DC battery and DC motor with pump

Solar Panel	
Items	Specifications
Model	SL-29-36P
Dimensions (L×W×T)	50.8 cm×35 cm×1.8 cm
Rated maximum power (Pmax)	20.0 W
Voltage at maximum power (Vmp)	18.48 V
Current at maximum power (Imp)	1.08 A
Weight	2.78 kg
No. of cells	36
Solar controller	
Item	Specification
Brand	Infrastructure Development Company Limited
Dimensions (L×W×T)	14 cm×12.4 cm×2.3 cm
For analog	12.0 V 20.0 A
For digital	12.0 V 10.0 A
DC battery	
Item	Specification
Model	Power Guard 12.0V – 8.2Ah UPS Battery
Type	Rechargeable sealed lead acid battery
Voltage	12.0V DC
Rated Current	8.2 Ah
DC motor with pump	
Brand	Flopump (Mini diaphragm pump)
Model	FL-2203
Voltage	12.0V
Max. Current	2.0A
Max. Pressure	0.45Mpa
Discharge	3.0 lit/min

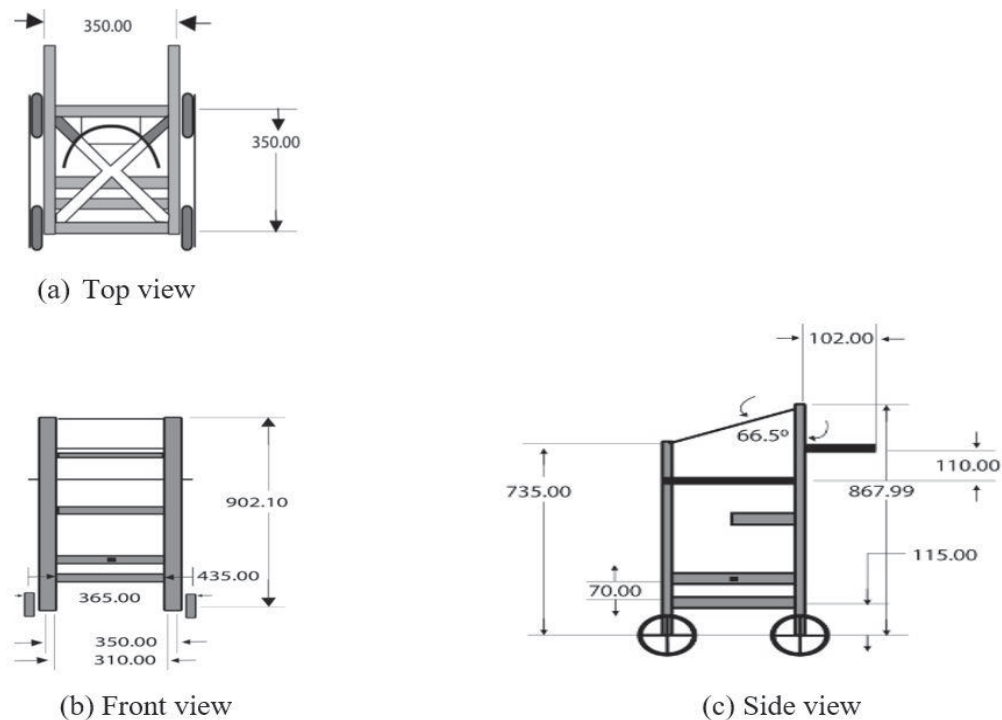


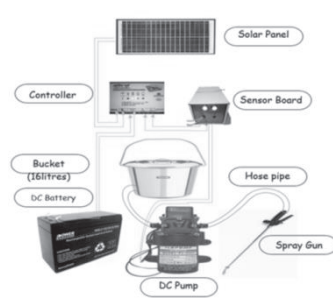
Figure 1. Design and development of the mainframe with dimensions (dimensions are in mm)

Fabrication of the machine: Solar panel was comprised of solar or PV cells made of semiconductor materials that convert sunlight directly into electricity. The solar panel mounted on the top and tilted to required angle 23.5° (Boxwell 2018) according to the manner of sunlight. The solar panel transmits current through the weir via controller and store charge in the DC battery. The acting of rotating motor could be controlled by sensor (i.e. water level indicator) attached with control unit (Figure 2). The frame was fabricated at the workshop. Each bolt was 8 mm diameter that was inserted to 4 holes by drilling mechanism. The same process was applied for 4 wheels. The plastic water tank was placed inside the frame for fixed in position- to weld half-circular additional support and placed on two cross-bar to its fixed position (Figure 1). For the battery, a stand was made with the help of paper sheet and enclosed by an angle bar, which attached with two screws. For solar panel was placed inclined on the top of the frame and fixed with the help four screw. The DC pump was placed on the bottom of the instrument with the help of four screws along with DC battery. For control unit namely as- IDCOL controller, two parallel consecutive bars was made on the frame to fix it with the help of four screw. A pipe was connected to storage tank with the help of connector to the pump. For the spraying purpose a spray gun was made with nozzle, which attached to a pressure gauge. The spray gun was connected to the hose pipe along with the pump, which discharged water. The sensor board was placed with the controller board to control mechanism of the instruments (Figure 3).

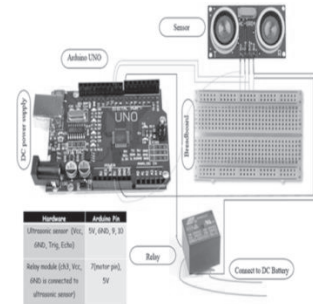


Figure 2. A photographic view of solar-powered sprayer

Experimental setup of solar powered hydraulic sprayer water level indicator:



(a)



(b)

Figure 3. Experimental setup of (a) solar powered hydraulic sprayer and (b) water level indicator

Working principle: The arrangement was accomplished by the use of solar panel and a diaphragm pump which runs on DC supply attached to the solar panel. The solar panel generates DC power, its positive and negative charges were connected to a battery in order to store the power, and then use this power when the sun lights are not present. In this sprayer, we used water level indicator indicating how much water present in the storage tank. When we spray in the field, the pump running until the empty of storage water, this mechanism was controlled by arduino sensor. By conducting this device, we can spray pesticides also to the herbs, and other agricultural plants (Figure 4).

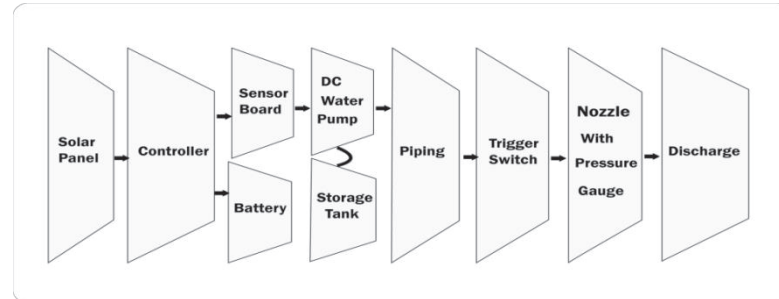


Figure 4. Flow chart of spraying system

Experimental site: The experiment was conducted in front of the Agricultural and Industrial Engineering (AIE) lab and backside of the central hospital also behind of guest house.

Technical evaluation

Charging time for battery: Charging time for battery was determined by using the following equation:

$$T_{\text{(charge)}} = \frac{R}{I} \quad \dots\dots\dots(1)$$

Where, $T_{\text{(charge)}}$ = Charging time for battery in hours, R = Battery rating in ampere hour, I = Total current transmitting by the solar panel in ampere

Discharging time while spraying: The discharging time while spraying in ideal condition was determined by the following equation (2):

$$T_{\text{(discharge)}} = \frac{R(\text{ideal})}{I(\text{pump})} \quad \dots\dots\dots(2)$$

Where, $T_{\text{(discharge)}}$ = Discharging time for battery in ideal condition while spraying in hours, $R(\text{ideal})$ = Battery rating ideally in ampere hour, $I(\text{pump})$ = Total current required for the pump.

$$\text{Actual discharging time} = \frac{\text{battery rating in ampere hour}}{\text{total current required for the pump}}$$

Discharge rate of the sprayer: The discharge rate of solar powered sprayer was measured from the volume of liquid discharged from the sprayer nozzle in the specified time. The measuring cylinder was used to collect the discharged liquid from the sprayer nozzle and a digital timer was used for recording the discharge time. The procedure was repeated three times and the mean discharge rate in litre per minute was calculated using the following equation (3) (kepner and EL Barger 2018)

$$DR = \frac{v}{t} \quad \dots\dots\dots(3)$$

Where, DR = discharge rate ($L \text{ min}^{-1}$), v = volume of liquid collected in cylinder (L) and t = time (min)

Banu *et al.*/design development and evaluation of solar powered sprayer

Application rate: The spray application rate depends on discharge rate and effective field capacity. The following equation (4) (Kepner and Barger 2018) was used to calculate the application rate for both single nozzle and double nozzle.

$$AR = \frac{Q}{EFC} \quad \dots\dots\dots(4)$$

Where, AR = application rate (L ha⁻¹), Q = discharge rate over nozzle (L min⁻¹) and EFC = effective field capacity (ha min⁻¹).

Efficiency of the pump: Efficiency of the pump was measured for both single nozzle discharge and double nozzle discharge. The following equation (5) was used to calculate the efficiency of the pump.

$$EP = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} \quad \dots\dots\dots(5)$$

Where, EP = efficiency of the pump (%)

Travelling speed: The speed of the machine was determined by using the following equation (6) (Hunt 2015).

$$S = \frac{d}{t} \quad \dots\dots\dots(6)$$

Where, S = travelling speed (ms⁻¹), d = distance traveled (m) and t = time (s)

Theoretical field capacity: The theoretical field capacity is the rate of field coverage that would be obtained if the machine performs its function 100% of the time at the rated forward speed and always covers 100% of its rated width (Kepner and Barger 2018) Therefore,

$$C_{th} = \frac{SW}{c} \quad \dots\dots\dots(7)$$

Where, C_{th} = theoretical field capacity (ha hr⁻¹), S = forward speed (km hr⁻¹), W = rated width (m) and c = constant (10).

Effective field capacity: The effective field capacity is the actual average rate of field coverage by the sprayer and calculated using the following equation (8) ((Hunt 2015).

$$C_{eff} = \frac{A}{T} \quad \dots\dots\dots(8)$$

Where, C_{eff} = effective field capacity (ha min⁻¹), A = total area covered (ha) and T = total time (min)

Field efficiency: It is the ratio of the effective field capacity to theoretical field capacity. The field efficiency of the sprayer was calculated using the following equation (9) (Kepner and Barger 2018).

$$F_{eff} = \frac{C_{eff}}{C_{th}} \times 100 \quad \dots\dots\dots (9)$$

Where, F_{eff} = Field efficiency (%), C_{eff} = Effective field capacity (ha hr⁻¹) and C_{th} = Theoretical field capacity (ha hr⁻¹).

Operating cost: The selection of machine for agricultural activities usually depends on least cost operation criteria. The operating cost of solar powered sprayer consists of (a) fixed cost (depreciation and interest on investment) and (b) variable cost (labor and repair and maintenance cost).

Fixed cost: In this study, the straight line method was used to calculate the depreciation using the following equation (10) (Barnerd and Nix 1979)

$$D = \frac{P-S}{L} \dots\dots\dots(10)$$

Where, D = depreciation cost (Tk yr⁻¹), P = purchase price of the machine or implement (Tk), Salvage value (Tk), and L = life of the machine or implement (yr).

The interest on investment in solar powered sprayer is included in fixed cost estimation. The following equation (11) was used for the calculation of interest on investment.

$$I = \frac{P+S}{2} \times i \dots\dots\dots (11)$$

Where, i = interest rate (decimal)

Variable cost: The variable cost is one, which changes when the level of output alters and vary in total in proportion to annual use but is approximately constant per ha (Barnerd and Nix 1979). The variable cost of solar powered sprayer depends on labor and repair & maintenance cost for each field operation. The cost of labor and repair & maintenance cost (1% of purchase price) was calculated in Tk hr⁻¹.

Operating cost: All calculated fixed cost and variable cost were converted into Tk ha⁻¹ and the summation of fixed and variable cost gave the operating cost of solar powered sprayer in Tk ha⁻¹.

$$TC = FC + VC \dots\dots\dots (12)$$

Where, TC = total operating cost (Tk), FC = fixed cost (Tk) and VC = variable cost (Tk)

Capital Recovery Factor (CRF): A capital recovery factor was used to combine the total depreciation and interest changed into a series of equal annual payments at compound interest. These payments plus the interest on the depreciated amount can be used to estimate the capital consumption (CC) of farm equipment as-

$$CC = (P - S) CRF + S \times i \dots\dots\dots (13)$$

Where, $CRF = i(1+i)^L / (1+i)^L - 1$, and i = interest rate (decimal)

Annual operating cost: The annual operating cost of solar powered sprayer was determined by the summation of fixed and variable cost. The following equation was used to calculate the annual operating cost of solar powered sprayer.

$$AC = FC + (VC \times U) \dots\dots\dots (14)$$

Where, AC = Annual cost (Tk), FC = fixed cost (Tk), VC = variable cost (Tk) and U = hours of use

Data analysis: After data collection, data were coded, compiled, tabulated and analyzed by MS Excel (Microsoft Excel, Microsoft, USA) in accordance with the objectives of the study.

RESULTS AND DISCUSSION

Measurement of pressure, flow rate, efficiency and plot performance curve

Where, Pump rated discharge, $Q = 3$ lit/min

Single nozzle discharge, $Q_1 = 2.5$ lit/min

Double nozzle discharge, $Q_2 = 2.8$ lit/min

$$\text{Efficiency of the pump, } Ep_1 = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} = \frac{2.5}{3} \times 100 = 83.33\%$$

$$\text{Efficiency of the pump, } Ep_2 = \frac{\text{Actual discharge}}{\text{Theoretical discharge}} = \frac{2.8}{3} \times 100 = 93.33\%$$

Table 2. Measurement of pressure and discharge

Trial No.	Nozzle	Pressure(P), bar	Discharge (Q), lit/min
1.	1	2.097	2.5
2.		2.049	2.55
3.		2.073	2.5
1.	2	1.549	2.8
2.		1.612	2.75
3.		1.581	2.7

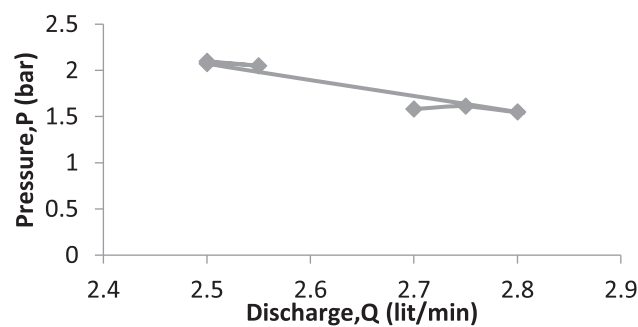


Figure 5. Performance curve

The highest pressure and lowest discharge developed in the pump was 2.097 bar and 2.5 lit/min for single nozzle (Table 2). On the other hand, the lowest pressure and highest discharge developed in the pump were 1.549 bar and 2.8 lit/min for double nozzle (Figure 5).

Measurement of spraying time and pressure of the sprayer

Table 3. Measurement of pressure and time

Sprayer type	Area	Pressure(P), bar	Trial No.	Spraying time	Average time
Solar power	1	4-4.5	1	1 min 20 sec	1 min 20 sec
			2	1 min 14 sec	
			3	1 min 26 sec	
Manual	1	1.5-2	1	2 min 17 sec	2 min 19 sec
			2	2 min 25 sec	
			3	2 min 15 sec	

The solar operated sprayer works on 4- 4.5 bar and coverage the spraying 1 decimal area, the average time 1 min 20 second required. On the other hand, the hand operated sprayer works on 1.5- 2 bar and coverage the spraying 1 decimal area, the average time 2 min 19 second required (Table 3). Here the proposed sprayer almost 58% time saving to hand operated sprayer.

Fabrication cost of the machine: The total fabrication cost of the sprayer was Tk 6230 (Table 4). It is inexpensive as compared to other machines that are available in the market. The fuel cost is zero due to operation by solar power (Table 5). Also one person, even a woman can operate this machine efficiently and smoothly.

Table 4. Fabrication cost of solar powered sprayer

Items	Cost (Tk)
Design of frame	1650
Coloring of frame	150
DC motor with pump	470
Hose pipe (10 feet)	80
Connector	100
Solar panel	700
Controller	220
DC Battery	850
Weir	60
Pressure gauge	250
Spray gun	140
Trolley wheel	160
Storage tank	180
Screw	50
Water level indicator	870
Others	300
Total cost (Tk)	6,230

Table 5. Technical performance of the solar powered sprayer

Particulars	Observations
Theoretical field capacity (ha hr ⁻¹)	0.08
Theoretical field capacity (ha day ⁻¹)	0.64
Effective field capacity (ha hr ⁻¹)	0.065
Effective field capacity (ha day ⁻¹)	0.52
Field efficiency (%)	81.2

Operating cost of the machine: The fixed cost and variable cost of a solar powered sprayer was 28 Tk ha⁻¹ and 773 Tk ha⁻¹. The operating cost of solar powered sprayer was 802 Tk ha⁻¹ which was lower than the manual operation (Table 6). The capital recovery factor, capital consumption and annual cost of the solar operated sprayer were 0.26, Tk 1520 and Tk 41665, respectively.

Table 6. Operating cost of solar powered sprayer

Item	Amount
Fixed cost	
Depreciation (Tk yr ⁻¹)	1122
Interest on investment (Tk yr ⁻¹)	343
Total fixed cost	
Tk yr ⁻¹	1465
Tk hr ⁻¹	1.83
Tk ha ⁻¹	28
Variable cost	
Labor (Tk hr ⁻¹)	50
Repair and maintenance(Tk hr ⁻¹)	0.25
Total variable cost	
Tk ha ⁻¹	773
Tk hr ⁻¹	50.25
Operating cost	
Tk hr ⁻¹	52.08
Tk ha ⁻¹	802
Capital Recovery Factor	0.26
Capital consumption (Tk)	1520
Annual cost(Tk yr ⁻¹)	41665

CONCLUSION

The battery actual discharging time is 4.1 hour and discharging time is 3.28 hour, when we did not use 20% of the rated current (Charvani *et al.* 2017). Then, we evaluated the performance of battery is 80% when weather is not good. Pump efficiency almost 83.33% found for single nozzle and 93.33% for double nozzle and the sprayer is 58% time saving than manual sprayer. The operating

cost of the machine was 802 Tk ha⁻¹. Also found capital recovery factor, capital consumption and annual cost of the solar operated sprayer were 0.26, Tk 1520 and Tk 41665, respectively. Besides these, it requires less effort and less maintenance cost than conventional sprayer.

REFERENCES

- Barnard CS and Nix JS. 1979. Farm Planning and Control, 2nd Edn. Cambridge University Press, Cambridge, UK.5(2): 185-197.
- Boxwell M. 2018. Solar Electricity Handbook - 2018 Edition: A Simple, Practical Guide to Solar Energy - Designing and Installing Solar Photovoltaic Systems. Greenstream Publishing. 186 pages.
- Charvani S, Sowmya K, Malathi M, Rajani P and Saibaba K. 2017. Design and Fabrication of a Solar Sprayer. International Journal of Science Technology and Management. 6(5): 6-14.
- Hunt D and Wilson D. Farm Power and Machinery Management. Eleventh edition. Waveland press, Inc.360.
- Kepner RA, Bainer R and Barger EL. 2018. Principles of farm machinery. CBS Publishers & Distributors.
- Krishnappa R, Venkartesh G, Prasad VNB, Kuri Y, Kumar VB and Hemanth M. 2017. Solar, Automatic and Manual Operated Diaphragm Pump and Grass Cutter. International Journal of Recent Trends in Engineering & Research. 3(6): 15-22.
- Kshirsagar SS, Umak P, Munde G and Mahale, PR. 2016. Design and Development of Agriculture Sprayer Vehicle. International Journal of Current Engineering and Technology (IJCET). 4: 405-408.
- Mishra A, Bhagat N and Singh P. 2019. Development of solar operated sprayer for small scale farmers. International Journal of Current Microbiology and Applied Sciences. 8: 2593-2596.
- Mukesh KM, Wadavane D, Ankit N, Dipak V and Chandrakant G. 2018. Solar operated pesticide sprayer for agriculture purpose. International Research Journal of Engineering and Technology (IRJET). 5(5): 3365-3369.



**IMPACT OF FACTORS AFFECTING CUSTOMER SATISFACTION TOWARDS
CORPORATE LOAN IN THE BANKING SECTOR OF BANGLADESH**

H. Begum, S. A. Khan and M. Aktar*

Department of Finance and Banking, Hajee Mohammad Danesh Science and Technology
University, Dinajpur, Bangladesh

*Corresponding Author: Email: mahbuba@tch.hstu.ac.bd; Cell Phone: +88-01848362483

DOI:<https://www.doi.org/10.59125/JST.20207>

ABSTRACT

The purpose of this paper is to determine customer satisfaction with corporate loans. Corporate lending in Bangladesh is making a large attitude. The assessment's primary goal is to conduct a thorough inquiry into the fulfillment of borrowers from Rupali Bank Limited. According to the review, Rupali Bank Limited has excellent employees in terms of behavior, and customer happiness is an important factor in evaluating the bank's performance. Using a self-administered survey, a confirmatory factor analysis, and a set of quality measures adopted from the existing literature. We reaffirm that factors of perceived satisfaction with regard to corporate loans in the context of Bangladesh include interest rate, information availability, policies and charges as well loan repayment procedure. For data analysis, factor loading through PCA and regression were applied. Results revealed that interest rate, information availability, policies and charges as well loan repayment procedure are positively related with customer satisfaction towards corporate loan. However, this study is a genuine contribution towards the corporate loan sector of Bangladesh. Our findings have relevance for academics and practitioners interested in understanding customers' ultimate needs.

Keywords: Customer satisfaction, corporate loan, collateral, interest rate, loan procedure

INTRODUCTION

Corporate loans are offered to business entities and availed for daily business needs, purchase of assets, starting a new venture, etc. Corporate lending is essentially the same thing as a personal loan, except instead of being made from a bank to an individual, it is made from a bank to a company. Customer satisfaction is defined as a measurement that determines how happy customers are with a company's products, services, and capabilities. Retail loans comprise consumer credit for specific purposes and credit for general use. The banking industry is highly competitive, with banks not only competing with each other; but also, with non-banks and other financial institutions. To retain customers, banks should try to make customers satisfied with their services and offerings (Ariff et al. 2013). Customer satisfaction is dictated by the perceived performance of a product relative to the buyers' expectations (Hawamdeh 2022). While there is broad agreement that high capital requirements make the banking system more resilient to adverse shocks, it is still debated whether high requirements also lead to reductions in credit availability

and increases in the cost of credit (Sengupta 2020). According to Dawit (2018), customer satisfaction is defined as the evaluation given by customers to certain bank products or services whether they have met their needs and prohibitions. Through interest-free savings and lending services, the banking industry has demonstrated its ability to address the financial needs of the community (Harun et al. 2020). Companies with a more satisfied customer base also have high economic returns. Such patterns have not been thoroughly investigated in earlier studies (Islam et al. 2021). A company's reputation is influenced by the quality of its products/services that satisfy consumer expectations and its great concern for social affairs. Bogati and Vongurai (2018) state that customer satisfaction is formed by buying and consuming a product so that customers can make an assessment of the benefits and price aspects of the product consumed customer satisfaction is the feeling of satisfaction possessed by the customer for the assessment that has been made of the fulfillment of expectations carried out by the Bank. Banks view lending not just as a crucial strategy for securing a long-term economic position, but also as an endeavor to cultivate positive relationships with people at all levels of society (Lombart and Louis 2014). In the banking sector, service quality has a favorable effect on customer satisfaction and these criteria are significantly associated with customer loyalty. Although there has been many research on satisfaction measurement in many fields, this study will provide a unique addition to Bangladesh's banking sector. This study will close this gap by concentrating exclusively on the various factor affecting customer satisfaction with regard to corporate loans in the context of Rupali Bank Limited. Also, this study aims to examine the impact of interest rate, the application process, information, policy and charges, loan repayment, fund and collateral, and other facilities (independent variable) on overall consumer satisfaction of Rupali Bank Ltd.

MATERIAL AND METHODS

Data and sample: The study is mainly based on primary data. For general concept development about the survey, questionnaires were used for collecting data about customer satisfaction towards corporate loans. Data were collected from 151 customers granted a corporate loan from Rupali bank limited, Bangladesh. Primary data have been collected using a well-designed questionnaire about the factors that affect customer satisfaction towards corporate loans. Information about respondents' perceptions about the factors was collected using a seven-point Likert scale where 7=Strongly agree, 6=Merely agree, 5=Agree, 4=Neutral, 3= disagree, 2=Merely disagree, 1= Strongly disagree.

Model specification: In this study the following regression model has been used:

$$OVS = \beta_1 INT + \beta_2 APN + \beta_3 INF + \beta_4 PLC + \beta_5 LRP + \beta_6 FNC + \beta_7 OTH + \beta$$

Here,

BSC= Overall Satisfaction, β =co efficient, ϵ =error term, INT = Interest Rate, APN = Application Process, INF = Information, PLC = Policy and Charges, LRP = Loan Repayment, FNC = Fund and Collateral, OTH = others

Table 1. Variables list

Determinates	Variable	Notation
Dependent Variable	Overall Satisfaction	OVS
Independent Variable	Interest Rate	INT
	Application Process	APN
	Information	INF
	Policy and Charges	PLC
	Loan Repayment	LRP
	Fund and Collateral	FNC
	others	OTH

Proposed Hypotheses

For the convergence of such information and proper decision-making by the users the following hypothesis has been taken into consideration:

H1: There is a positive relationship between interest rate and overall satisfaction.

H2: There is a positive relationship between the application process and overall satisfaction.

H3: There is a positive relationship between information and overall satisfaction.

H4: There is a positive relationship between Policy and charges and overall satisfaction.

H5: There is a positive relationship between Loan Repayment and overall satisfaction.

H6: There is a positive relationship between Fund and Collateral and overall satisfaction.

H7: There is a positive relationship between other facilities and overall satisfaction.

RESULTS AND DISCUSSION

Table 2. Percentage of Male and Female

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	127	84.7	84.7	84.7
	Female	23	15.3	15.3	100.0
	Total	150	100.0	100.0	

Table 2 shows the percentage of male and female participants is 84.7% and 15.3% respectively.

Table 3. Loan Amount level

Loan Amount level					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10-20	62	41.3	41.3	41.3
	20-30	77	51.3	51.3	92.7
	30-40	10	6.7	6.7	99.3
	40-50	1	0.7	0.7	100.0
	Total	150	100.0	100.0	

Table 3 represents the amount level of borrowers from Rupali Bank Ltd. 41.3% of borrowers were granted 10 to 20 lakhs, 51.3% of borrowers were granted 20 to 30 lakhs, 6.7% of borrowers were granted 30 to 40 lakhs and 0.7% of borrowers were granted 40 to 50 lakhs.

Descriptive Statistics

Table 4 shows that OVS has the highest mean value is 5.8117. Information and Interest also have a higher mean value which is 5.8578 and 4.8711 respectively. On the other hand, APN, PLC, and LRP have a positive mean value which means the better performance of the bank. On the other hand, APN has the highest standard deviation which is 1.13876. OVS, INT, INF, PLC, LRP, FNC, and OTH has positive standard deviation which determines the good performance of Rupali Bank Ltd. INF is the main power of Rupali Bank Ltd because it has the highest number of Min and Max values.

Table 4. Summary of statistics

Descriptive Statistics										
	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
OVS	150	2.75	6.75	5.8117	.70350	.495	-2.338	.198	5.606	.394
INT	150	2.67	6.33	4.8711	.55936	.313	-.018	.198	2.084	.394
APN	150	2.33	6.00	3.8578	1.13867	1.297	.153	.198	-1.347	.394
INF	150	3.33	6.67	5.5689	.84658	.717	-.734	.198	-.567	.394
PLC	150	2.33	7.00	4.4467	.91048	.829	1.247	.198	2.079	.394
LRP	150	1.67	7.00	4.5356	.95139	.905	-.981	.198	1.480	.394
FNC	150	2.33	6.67	4.2289	.83200	.692	1.064	.198	1.030	.394
OTH	150	1.33	7.00	4.4711	.81484	.664	.192	.198	1.173	.394

KMO Test Value and Factor Loading

Table 5. KMO Test Value

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.709
Bartlett's Test of Sphericity	Approx. Chi-Square	2197.972
	df	300
	Sig.	0.000

Table 5 represents the KMO test value is 0.709 which is satisfactory.

Factor Loadings Using Varimax Rotation (PCA) Method

Table 6 represents the factor loading value using the varimax rotation (PCA) method.

Table 6. Factor Loadings Using Varimax Rotation (PCA) Method

Factor Loadings Using Varimax Rotation (PCA) Method			
Item	Factor Loadings	Factor Name	
FACTOR 1			
Getting a corporate loan is not difficult	0.689	Overall Satisfaction	
Corporate loan interest is suitable	0.753		
Employers of Rupali Bank are very hospitable	0.674		
Satisfied with the co-operation given	0.684		
FACTOR 2			
The interest rate is low	0.772	Interest Rate	
Some institutes offer a bigger amount	0.655		
Adjust the interest rate policy changed by the government	0.745		
FACTOR 3			
Extensive application process	0.729	Application Process	
The application process is not difficult	0.695		
Time-consuming process	0.734	Information	
FACTOR 4			
Collect information from direct brunch	0.840		
Collect information from websites and mail	0.772		
Collect information from advertising and article	0.770		
FACTOR 5			
Process is transparent	0.690	Policy and Charges	
Policy is strict	0.633		
The application fee is common	0.668		
FACTOR 6			
The repayment process is smooth	0.874	Loan Repayment	
The repayment process is flexible for all	0.796		
Provide facility for early termination	0.685		
FACTOR 7			
Access more funds than a personal loan	0.600	Fund and Collateral	
Restriction on fund usage	0.769		
Collateral is needed	0.809		
FACTOR 8			
Tax benefit	0.785	Other facilities	
Long wait for credit decision	0.792		
Encourage people to get into business	0.634		

Pairwise Correlation**Table 7. Pairwise Correlation**

	OVS	INT	APN	INF	PLC	LRP	FNC	OTH
OVS	1							
INT	.097	1						
APN	-.048	.398**	1					
INF	.355**	.077	-.073	1				
PLC	.048	.351**	.541**	-.182*	1			
LRP	.209*	-.011	-.154	-.231**	.031	1		
FNC	-.099	.226**	.529**	-.186*	.700**	-.179*	1	
OTH	-.154	.453**	.535**	.137	.237**	-.399**	.315**	1

Table 7 indicates the Pearson Correlation. Basically, correlation shows the relationship between overall satisfaction (Dependent Variable) and another variable which are INT, APN, INF, PLC, LRP, FNC, and OTH (Independent variable). The most significant relationship is found between the information (0.355**) and overall satisfaction. Loan Repayment also has a significant value which means this is a positive relationship between them. Whereas fund and collateral have a negative relationship with overall satisfaction.

Table 8. Regression results

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.504	.254	.217	.62104	1.647

a. Predictors: (Constant), OTH, INF, PLC, LRP, INT, APN, FNC

b. Dependent Variable: OVS

Here, adjusted R^2 is .217 which represents that the independent variable combinedly can explain 21.7% of the dependent variable.

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.780	7	2.683	6.956	.000 ^b
	Residual	55.153	143	.386		
	Total	73.933	150			

a. Dependent Variable: OVS

b. Predictors: (Constant), OTH, INF, PLC, LRP, INT, APN, FNC

Here, *the p* is less than of 0.05 lead to indicate that the independent variable have a significant impact on the overall customer satisfaction.

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.937	.724		4.056	.000
	INT	.150	.109	.120	1.382	.169
	APN	.036	.062	.058	.580	.563
	INF	.356	.063	.435	5.618	.000
	PLC	.121	.086	.157	1.403	.163
	LRP	.153	.062	.207	2.456	.015
	FNC	-.069	.092	-.082	-.751	.454
	OTH	-.204	.085	-.238	-2.403	.018

a. Dependent Variable: OVS

Here coefficients of all the independent variables are presented. From the value of the coefficients, it's been observed that information, loan repayment, and other variable have a significant impact on overall satisfaction.

Table 9. Hypothesis testing result

Hypothesis	Tool	Explanation	Result
H1: Interest rate has a positive impact on overall satisfaction.	Correlation	Table 7 shows that $r = 0.097$ which represents a weak but positive correlation between interest rate and overall satisfaction.	Accepted
H2: Application process rate has a positive impact on overall satisfaction.	Correlation	Table 7 shows that $r = -0.048$ which represents a negative correlation between the application process and overall satisfaction.	Rejected
H3: Information has a positive impact on overall satisfaction.	Correlation	Table 7 shows that $r = 0.355$ which represents a strong positive correlation between information and overall satisfaction.	Accepted
H4: Policy and charges have a positive impact on overall satisfaction.	Correlation	Table 7 shows that $r = 0.048$ which represents a weak but positive correlation between policy & changes and overall satisfaction.	Accepted
H5: Loan Repayment has a positive impact on overall satisfaction.	Correlation	Table 7 shows that $r = 0.209$ which represents a positive correlation between loan repayment and overall satisfaction.	Accepted
H6: Fund and Collateral have a positive impact on Overall Satisfaction.	Correlation	Table 7 shows that $r = -0.099$ which represents a negative correlation between the fund & collateral and overall satisfaction.	Rejected
H7: Other facilities have a positive impact on Overall Satisfaction.	Correlation	Table 7 shows that $r = -0.154$ which represents a negative correlation between the other facilities and overall satisfaction.	Rejected

CONCLUSION

Banks should focus on the prosperity of the country to accommodate the growing demand for a diverse variety of banking services. Though banks can do that by assuring adequate personnel and material resources to deliver the best service to their customers for offering great services. Nonetheless, they should focus more on customer-tailored services and make advances in banking. The research findings clearly show that the client prefers the drive toward simplicity and convenience in banking, and hence banks should seek alternative strategic approaches geared to improve loan service delivery. These findings will be useful both practically and conceptually. This analysis, which provides new insight, will have a huge impact on the banking market in Bangladesh. The findings of this study will also assist policymakers in taking action to improve performance and obtain a durable competitive edge over competitors. This research can be used by banks to improve their services, maintain good and strong relationships with their customers, and increase client retention. However, this study used data from 150 respondents for this research. In the near future, new factors can be added to enrich the time period. Further research can be conducted by including other banks and comparing them.

REFERENCES

- Ariff MSM, Yun LO, Zakuan N and Ismail K. 2013. The impacts of service quality and customer satisfaction on customer loyalty in internet banking. *Procedia-Social and Behavioral Sciences*, 81: 469-473.
- Bogati D and Vongurai. 2016. Determinants of Customer Satisfaction And Customer Loyalty In E-Banking: A Case Study of Thailand's Selected Commercial Banks in Bangkok's Central Business Area. *International Research E-Journal on Business and Economics*. 2(2): 22-32.
- Dawit JB. 2018. The Effect of Perceived Service Quality on Customer Satisfaction in Private Commercial Banks of Ethiopia: The Case of Selected Private Commercial Banks at Dire Dawa Administration. *Business Economic Journal*. 9(2): 358-367.
- Harun MS, Hussainey K, Kharuddin MKA and Farooque O. 2020. CSR disclosure, corporate governance, and firm value: a study on GCC Islamic banks. *International Journal of Accounting Information Management*. 28 (4): 607–638.
- Hawamdeh AKG. 2022. The Impact of Corporate Social Responsibility on the Customers' Loyalty in the Jordanian Banking Sector: the mediating role of customer satisfaction. *Journal of Southwest Jiaotong University*. 57(2): 32-40.
- Islam T, Islam R, Pitafi AH, Xiaobei L, Rehmani M, Irfan M and Mubarak MS. 2021. The impact of corporate social responsibility on customer loyalty: the mediating role of corporate reputation, customer satisfaction, and trust. *Sustainability journal Production and Consumption*. 25: 123–135.
- Lombart C and Louis D. 2014. A study of the impact of Corporate Social Responsibility and price image on retailer personality and consumers' reactions (satisfaction, trust, and loyalty to the retailer). *Journal of Retailing Consumer Service*. 21 (4): 630–642.
- Sengupta R. 2020. Assessing Market Conditions ahead of Quantitative Tightening. *Economic Bulletin*. (July 11, 2022): 1-4.



INVESTIGATING THE IMPACT OF SERVICE DIMENSIONS ON CUSTOMER SATISFACTION AND CUSTOMER LOYALTY: A CONTEXT ON EMERGING SERVICE ECONOMY

T. Islam^{1*}, S. N. Habib², R. Islam³ and R. Sharmin²

¹Department of Marketing, ²Department of Management, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, ³Laxmipur Rajshahi, Bangladesh

*Corresponding Author: Email: tishimin@gmail.com; Cell Phone:+8801729663084

DOI:<https://www.doi.org/10.59125/JST.20208>

ABSTRACT

This is an empirical endeavor to find out the impact of service dimensions on customer satisfaction and how customer satisfaction affects customer loyalty. In order to measure service quality SEVQUAL model was used based on five dimensions of quality -tangibility, empathy, responsiveness, reliability and assurance and to investigate which service determinants have direct impact on customer satisfaction correlation between the determinants and customer satisfaction was determined. Primary data was collected from 308 respondents who are customers of financial institutions in Bangladesh and analyzed using SPSS-17. Our empirical findings reveal that independent variables, the five dimensions of service quality is strongly correlated with customer satisfaction. Customer satisfaction has positive relationship with customer loyalty. Furthermore, it is found that the most important aspect is the level of assurance for achieving customer satisfaction and customer satisfaction is a strong predictor of customer loyalty.

Keywords: Satisfaction, SEVQUAL model, customer loyalty, SPSS, regression analysis.

INTRODUCTION

Service industry is growing at relatively faster rate as its contribution in world trade has increased from 9 percent in 1970 to 20 percent in 2019 and it is predicted that service will contribute about one-third in world trade by 2040 (WTO 2019). Intangibility feature of service makes it really tough for service providing organizations to have a unified definition and benchmarks of good service quality besides that the development in technology has changed the dimensions of relationship between customers and organizations engaged in service industry, that's why the quality of customer service, customer satisfaction and loyalty are becoming key for any organization to provide excellent quality (Marić *et al.* 2016).

The concept of service quality evolved during 1980s by the research of Churchill and Surprenant (1982) which has been popularized by the research and writings of Berry *et al.* (1988) and Parasuraman *et al.* (1988) through the theory of customer satisfaction and SERVQUAL-a measure to assess service quality (Fida *et al.* 2020). Though quality has not been perceived uniformly in all sectors, but in quest to defined service quality, Lewis (1993) defined service quality is how well the service delivery matches with customers' expectations. So service quality is result of assessment done by consumers between what they expect with their perception of what they get (Yadav and Rai 2019). Parasuraman *et al.* (1988), developed SERVQUAL as a measure to assess

service quality through five dimensions of quality. These dimensions include five areas that are tangibles, reliability, responsiveness, assurance, and empathy. They developed a scale consisting of 22 variables classified into the aforesaid dimension. The quality of delivery of service plays a major role in forming customer satisfaction and also has an impact on the relationship between the company and the customers (Amin and Isa 2008). Customer satisfaction is undoubtedly believed as a key to success as satisfied customer groups are critical for an organization's survival in terms of profit and also to be competitive in the market (Kant and Jaiswal 2017). Customer satisfaction has been identified as an antecedent of service quality of banks and found a significant positive relationship between service quality and customer satisfaction (Leninkumar 2017; Akhtar 2011; Yilmaz *et al.* 2006). Organizations need to improve customer satisfaction to sustain the level of customer loyalty (Heskett *et al.* 2008). Researchers have found a significant relationship between customer satisfaction and customer loyalty (Leninkumar 2017). In different countries, the SERVQUAL model and the scale has been used to assess service quality in banking sectors (Fida *et al.* 2020; Kant and Jaiswal 2017; Banerjee and Sah 2012; Selvakumar 2015). So SERVQUAL models are definitely a popular model that can be used to assess service quality in the banking sector (Kant and Jaiswal 2017). But it's difficult to generalize the findings of these types of studies conducted in foreign and in different passages of time, so this research work is undertaken to find out the service quality perception of bank customers of Bangladesh in Covid-19 pandemic time.

This study makes two main contributions. First, it adds to existing literature by providing empirical evidence for better understanding the relationship between customer satisfaction and customer loyalty in the context of a developing country. Second, the findings of this research will not only provide financial institutions with useful information on how to evolve non-price competition strategies to retain customers, but also reveal the highly valued service items appreciated by service receivers, which will help policy makers of service economy in deciding how to allocate their scarce resources.

RESEARCH OBJECTIVE

1. To assess the level of satisfaction regarding the quality of service provided by financial institutions.
2. To measure the impact of financial customer satisfaction on customer loyalty.

Hypothesis 1: Customer satisfaction is influenced by the quality of service provided by financial institutions.

Hypothesis 2: There is an impact of financial customer satisfaction on customer loyalty.

MATERIALS AND METHODS

This study has used a questionnaire designed using a seven-point Likert scale, where 7= Strongly Agree, 6= Agree, 5= More or less Agree, 4= Undecided, 3= More or less Disagree, 2= Disagree and 1= Strongly disagree. We selected only 28 banks (5 State Owned Commercial Bank, 1 Specialized Bank and 22 Private Commercial Bank) as sample. Therefore, the clients of those banks were considered as respondents of the study. The structured questionnaire survey was conducted using Google form, as it was during Covid-19 pandemic time so in person structured

questionnaire survey wasn't possible and that's why judgmental as well as convenience sampling method was used for the study. Also only 308 complete questionnaires were received during the targeted time of study that is why the sample size is only 308 respondents. Table 1 represent the demographic profile of the respondents, where female was 63% and male was 37% and below ten thousand income range 92.9% respondents resides and from ten to twenty range 20.1% respondents and more than twenty thousand range 37% respondent resides.

Here we analyzed the relation between the independent variables- tangibility, empathy, responsiveness, reliability and assurance with dependent variable that is customer satisfaction. Another relationship was assessed where customer satisfaction is the independent variable and customer loyalty is dependent. MS Excel was used to carry out calculations in some cases. SPSS (Statistical Package for Social Science) software was used for descriptive analysis and regression analysis as well.

RESULT AND DISCUSSION

At first in this section the reliability and validity of the construct has been tested and then descriptive statistical analysis has been carried out for each study constructs. Then, a hypothesis test has been conducted to find out the relationships between each of the variables of this study. Finally, this section concludes with the summary of findings related to the hypotheses concerning service quality attributes, customer satisfaction and customer loyalty.

Table 1. Sample Demography

Variables	Values	Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Female	194	63	63	63
	Male	114	37	37	100
Income	<10,000	132	92.9	92.9	42.9
	10,000 to 20,000	62	20.1	20.1	63
	20,000>	114	37.0	37.0	100
Account Type	Current	70	22.7	22.7	22.7
	Savings	184	59.7	59.7	82.5
	Fixed Deposit	24	7.8	7.8	90.3
	Any other	30	9.7	9.7	100.0

Table 2. Reliability and Validity

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.942	0.942	6

Table 3. Total Statistics

Dimensions	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Tangibility	26.5180	31.237	0.810	0.715	0.933
Reliability	26.4032	30.614	0.851	0.778	0.928
Responsiveness	26.6487	30.088	0.878	0.784	0.924
Assurance	26.3378	30.575	0.858	0.743	0.927
Empathy	26.7552	29.933	0.816	0.705	0.932
Satisfaction	26.6032	31.525	0.739	0.573	0.941

The reliability test of the current study has pointed out that in terms of reliability the most important figure is the Alpha value. This is Cronbach's Alpha, which, in this case is 0.942 in Table 2. Pallant (2001) stated that if any of the values in the Cronbach's Alpha If Item Deleted Column Table 2 are higher than the final alpha value then the researcher may want to consider removing this item from the scale. In this study, all the values are less than the final Alpha value; therefore, all the values are reliable.

Reliability statistics Table 2 shows that the Alpha value is 0.942. The column (Cronbach's Alpha if Item Deleted) reveals that the Cronbach's Alpha of Customer Satisfaction is 0.941 (see table 3) which is less than the original alpha value, therefore the Alpha value of Customer Satisfaction is reliable. It has been observed that the Alpha value of customer Satisfaction also exceeded Nunnally and Bernstein (1994) recommended criterion of 0.70 for scale reliability.

The minimum and maximum value for customer satisfaction is 1 to 7 and the Mean and Standard Deviation is 5.25 and 1.26 respectively. The mean value of customer satisfaction is more than the neutral value that is 3.5. Customer loyalty ranges from 1 to 7 and the Mean and Standard Deviation is 5.27 and 1.31 respectively. It has been observed in the Table 4 that almost all the Mean are similar.

Table 4. Descriptive Statistics

Dimensions	N	Minimum	Maximum	Mean	Std. Deviation
Satisfaction	308	1.00	7.00	5.2500	1.26716
Tangibility	308	1.00	7.00	5.3352	1.20946
Reliability	308	1.00	7.00	5.4500	1.22481
Responsiveness	308	1.00	7.00	5.2045	1.24583
Assurance	308	1.00	7.00	5.5154	1.21990
Empathy	308	1.00	7.00	5.0981	1.33531
Loyalty	308	1.00	7.00	5.2760	1.31375
Valid N (list wise)	308				

Pearson Correlation

A correlation coefficient is a very useful way to summarize the relationship between two variables with a single number that falls between -1 and +1. Morgan et al. (2004) stated that: -1.0 (a perfect negative correlation), 0.0 (no correlation) +1.0 (a perfect positive correlation). Pallant (2001) suggested the following interpretation of r-value. r-value will indicate the strength of the relationship between two variables. $r = 0.10$ to 0.29 or $r = -0.10$ to -0.29 small, $r = 0.30$ to 0.49 or $r = -0.30$ to -0.49 medium, $r = .50$ to 1.0 or $r = -0.50$ to -1.0 large. The Pearson correlation analysis obtained for the three intervals scaled variables in the Table: 5 above. The sample size (N) is 308 and the significant level is 0.01 ($p < 0.01$).

Table 5. Correlations

	Dimensions	1	2	3	4	5	6
1	Satisfaction						
2	Tangibility	0.593*					
3	Reliability	0.649*	0.818*				
4	Responsiveness	0.687*	0.770*	0.827*			
5	Assurance	0.676*	0.756*	0.777*	0.794*		
6	Empathy	0.716*	0.667*	0.687*	0.776*	0.775*	
7	Loyalty	0.840*	0.540*	0.584*	0.641*	0.612*	0.690*

**. Correlation is significant at the 0.01 level (1-tailed).

HYPOTHESIS TESTING

H1: Customer satisfaction is influenced by the quality of service provided by financial institutions

Table 6. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.757 ^a	0.573	0.566	0.83450

a. Predictors: (Constant), Empathy, Tangibility, Assurance, Reliability, Responsiveness

** Significant at the level of 0.005

From the Table 6, it had been seen that R value was 0.757. Therefore, R value (0.757) for the five dimensions suggested that there was a strong effect of five independent variables on dependent variable (customer satisfaction). It is also observed that the coefficient of determinations i.e. R-square value was 0.573, which representing that 57.3% variation of the dependent variable (Customer Satisfaction) is due to the independent variables (Empathy, Tangibility, Assurance, Reliability, Responsiveness) of financial institution in Bangladesh.

In the Table 7, Unstandardized coefficients indicated how much the dependent variable (Customer Satisfaction) varies with independent variable (five dimensions), when all other independent variables are held constant. The beta coefficients indicated that how and to what extent the dimensions such as tangibility, reliability, responsiveness, assurance, and empathy influence

customer satisfaction. It had been found that, reliability ($\beta = 0.172$, $t = 2.101$, $p < 0.001$), responsiveness ($\beta = 0.161$, $t = 1.970$, $p < 0.001$) and empathy ($\beta = 0.369$, $t = 5.942$, $p < 0.001$), had the highest influence on customer satisfaction whereas, tangibility ($\beta = -0.037$, $t = -0.505$, $p < 0.001$) and assurance ($\beta = 0.152$, $t = 1.989$, $p < 0.001$), had relatively lower impact on customer satisfaction of financial institutions of Bangladesh.

H2: There has impact of financial customer satisfaction on customer loyalty.

Table 7. Coefficients

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.950	0.235		4.045	0.000
	Tangibility	-.037	0.074	-.035	-.505	0.614
	Reliability	0.172	0.082	0.166	2.101	0.036
	Responsiveness	0.161	0.082	0.158	1.970	0.050
	Assurance	0.152	0.077	0.147	1.989	0.048
	Empathy	0.369	0.062	0.389	5.942	0.000

a. Dependent Variable: Satisfaction

Table 8. Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.840(a)	0.706	0.705	0.71299

A Predictors: (Constant), Satisfaction

** Significant at the level of 0.005

From the Table 8, it had been seen that R value was 0.840. Therefore, R value (0.840) for the customer satisfaction suggested that there was a strong effect of this independent variable (customer satisfaction) on dependent variable (customer loyalty). It also observed that the coefficient of determination i.e. the R-square value was 0.706, which representing that 70% variation of the dependent variable (customer loyalty) is due to the independent variable (customer satisfaction) of service industry in Bangladesh.

From the Table 9, Unstandardized coefficients indicated how much the dependent variable (Customer loyalty) varies with independent variable (Customer satisfaction), when all other independent variables are held constant. The beta coefficients indicated that how and to what extent the factor customer satisfaction influence customer loyalty. It had been found that, customer satisfaction ($\beta = 0.840$, $t = 27.135$, $p < 0.001$) had the highest influence on customer loyalty of service industry in Bangladesh.

Table 9. Coefficients (a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	.701	.173		4.043	.000
	Satisfaction	.871	.032	.840	27.135	.000

a Dependent Variable: Customer loyalty of financial institutions

** Significant at the level of 0.005

CONCLUSIONS

On the basis of analysis of data, the research finds the effect of service quality dimension on customer satisfaction. From the findings of Table 5, it can be seen that the correlation (*r*) of tangible, reliability, responsiveness, assurance and empathy all the values are more than 0.50, that means determinants of service dimension has strong positive impact on customer satisfaction that means service quality can have significant impact in satisfying customers in the service economy in Bangladesh. The value of Beta co-efficient is 0.840 that signifies that customer satisfaction has strong correlation with service quality and customer loyalty. Based on the research findings, there are some suggestions. This research shade light on the fact that service quality and customer satisfaction are correlated. The service quality provided by the financial institution needs to be improved on tangibility, responsiveness and empathy dimensions in order to improve customer satisfaction. Also it has found a strong correlation between customer satisfaction and customer loyalty. In order to maintain and improve customer loyalty through improved service quality, the management should pay attention to directly related process of services to the customers such as ease terms of loans, prompt problem solving. This study was conducted during pandemic situation so it has used purposive sampling method and also the sample size is small which has made the scope of the study limited for different statistical measures. Also it was difficult to get data on such topic as customers are not comfortable to share feeling and data regarding financial issue. Future research is expected to conduct a deeper analysis of the theory used in this research so that more complex measurement of the indicators can be undertaken.

REFERENCES

- Akhter W, Abbasi AS, Ali I and Afzal H. 2011. Factors affecting customer loyalty in Pakistan, *African Journal of Business Management*. 5(4): 1167-1174.
- Ajmal H., Khan R. A., and Fatima M. (2018). Impact of service quality on customer satisfaction in banking industry of Pakistan: A case study of Karachi. *Journal of Social and Administrative sciences*, 5(3): 219-238.
- Amin M, and Isa Z. 2008. An examination of the relationship between service quality perception and customer satisfaction: A SEM approach towards Malaysian Islamic banking. *International Journal of Islamic and Middle Eastern Finance and Management*. 1(3): 191–209.
- Berry L, Zeithaml V and Parasuraman A. 1988. “The Service-Quality Puzzle”, *Business Horizons*. 31(5): 35-43.

- Banerjee N. and Sah S. 2012. "A comparative study of customers' perceptions of service quality dimensions between public and private banks in India", *International Journal of Business Administration*. 3(5): 33-44.
- Churchill JGA, and Surprenant, C. (1982). An investigation into the determinants of customer satisfaction. *Journal of marketing research*, 19(4): 491-504.
- Fida BA, Ahmed U, Al-Balushi Y and Singh D. 2020. Impact of service quality on customer loyalty and customer satisfaction in Islamic banks in the Sultanate of Oman. *Sage Open*. 10(2): 2158244020919517.
- Heskett JL, Jones TO, Loveman, GW, Sasser, WE and Schlesinger LA. 2008. Putting the service-profit chain to work. *Harvard Business Review*. 86: 118–129. Retrieved from Islamic Financial Services Board. (2018). <http://www.ifsb.org/>
- Kant R and Jaiswal D. 2017. The impact of perceived service quality dimensions on customer satisfaction: An empirical study on public sector banks in India. *International Journal of Bank Marketing*. 35 (3): 411-430. Retrived from DOI 10.1108/IJBM-04-2016-0051.
- Leninkumar V. 2017. The relationship between customer satisfaction and customer trust on loyalty. *International Journal of Academic Research in Business and Social Sciences*.7: 450–464.
- Lewis BR. 1993. Service quality: recent developments in financial services. *International Journal of Bank Marketing*. 119(6): 19-25.
- Marić D, Marinković V., Marić R, and Dimitrovski, D. (2016). Analysis of tangible and intangible hotel service quality components. *Industrija*, 44(1), 7-25. doi. 10.5937/industrija1-8437.
- Nunnally JD, Bernstein IH. *Psychometric theory*. 3. New York: McGraw-Hill; 1994.
- Pallant, J. (2001), *SPSS survival manual - a step by step guide to data analysis using SPSS for windows (version 10)*, Buckingham Open University Press.
- Parasuraman A, Zeithaml VA and Berry LL. 1988. SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*. 64(1): 12–40.
- Selvakumar JJ. 2015. Impact of service quality on customer satisfaction in public sector and private sector banks, *Purushartha: A Journal of Management, Ethics and Spirituality*. 8(1): 1-12.
- Yadav MK, and Rai AK. 2019. An assessment of the mediating effect of customer satisfaction on the relationship between service quality and customer loyalty. *IUP Journal of Marketing Management*. 18(3): 7-23.
- Yilmaz V, Çelik EH and Ekiz HE. 2006. "Kuruma ba ğlılı ğı etkileyen faktörlerin yapısal e ğitlik modelleriyle ara ğtırılması: özel ve devlet bankası örne ği", *Anadolu Üniversitesi Sosyal Bilimler Dergisi*. 2: 171-184.
- Zeithaml V, Berry L, and Parasuraman A. 1996. The behavioral consequences of service quality. *Journal of Marketing*. 60: 31–46.
- World Trade Organization. 2019. https://www.wto.org/english/res_e/booksp_e/02_wtr19_1_e.pdf



THE IMPACT OF PACKAGING ON CONSUMER BUYING DECISION: AN APPLICATION ON CONSUMER GOODS

M. J. Uddin^{1*}, H. Begum² and M. A. Rouf¹

¹Department of Marketing, ²Department of Finance and Banking, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh

*Corresponding Author: Email: jamal@hstu.ac.bd; Cell Phone: +8801716442883

DOI:<https://www.doi.org/10.59125/JST.20209>

ABSTRACT

The purpose of this research was to know the impact of packaging on consumer buying decision process. Both qualitative and quantitative research approach were used to achieve the objectives of the study. Respondents were selected using convenience sampling method for collecting primary data through self administrated questionnaire. 97 completely filled up questionnaires were authentic for research study. Six factors of packaging were considered as independent variables to evaluate the respondents' opinion. The study result shows that all factors have a positive and significant relationship with buying decision of product with the highest correlation value of packaging color (.810) followed by other factors. Quality of packaging materials has highest positive impact on consumer buying decision process ($\beta=.158$, $t= 4.215$, $p=0.001 < 0.05$), followed by packaging color ($\beta=.116$, $t= 3.281$, $p=0.000 < 0.05$), followed by printed information of package ($\beta=.224$, $t= 3.211$, $p=0.000 < 0.05$) and other factors. R square value shows 58.2% variance in consumer buying decision depends on independent variables.

Keywords: Consumer buying decision, packaging color, label of package, printed information of package

INTRODUCTION

The globalization of the world has made necessary for manufacturers to present their products in an attractive manner and differentiate their products from the competitors' products. Consumers nowadays are bombarded with too many marketing stimuli, clues in order to being attracted by different companies. Companies are more concerned on individual consumer behavior. It helps them to yield information about how the consumers think, feel and choose their products. Such a situation has increased the choice opportunities offered to consumers and engaged companies into a fierce competition race. The purchase decision is a series of choices or judgment made by a consumer prior to making a purchase that begins once the consumer has established a willingness to buy. The consumer must then decide where making the purchase, what brand, model, or size to purchase, when to make the purchase, how much to spend, and what method of payment will be used (Zekiri and Hasani 2015). Packaging is an important part of the branding process as it plays a role in communicating the image and identity of a company (Smith 2004). Kamal *et al.* (2012) found packaging assists as a promotional instrument besides other basic functions. Packaging is important

factor for the consumer buying decision and communication of information about the product (Rundh 2013). Firms' interest in package as a tool of sales promotion is growing increasingly (Mutil 2012). Keller (2019) emphasis on packaging color. According to Lamb *et al.* (2011) in their book 'Essentials of Marketing' think that packaging has four distinct marketing functions. Again Rita (2009) explained package attracts consumer's attention to particular brand, enhances its image, and influences consumer's perceptions about the product. Underwood *et al.* (2009) and Silayoi & Speece (2004) found out that packaging elements act as a tool for differentiation. Ahmed *et al.* (2014) found packaging portrays the knowledge about the product and has great impact on consumer buying behavior. Most product labels provide the information via packaging (Ampuero and Vila 2006). Adam and Ali (2014) found that packaging graphics, information are largely and positively associated with customers purchasing behavior. Right packaging can help a brand carve a unique position in the marketplace and in the minds on consumers Alice Louw (2006). Packaging as a silent salesman is directed toward influencing the point of purchase buying decision. The aim of this study is to identify the influence of packaging and their impact on consumer buying decision process in the perspective of consumer goods such as detergents, soap, shampoo, food items and other consumer durables.

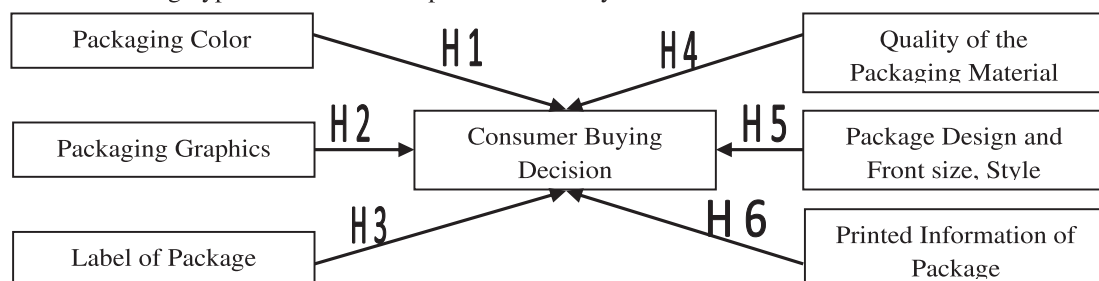
MATERIALS AND METHODS

This study was descriptive in nature. Both qualitative and quantitative research approach were used to achieve the objectives of the study. The people of Rajshahi City Corporation area were the population for this study. The convenience sampling was used and the primary data was collected from the respondents in different shopping malls in city corporation area through self administrated questionnaire. Six factors of packaging were considered as independent variables and a five-point Likert scale (Likert, 1932) (1 = strongly disagree and 5 = strongly agree) was used to evaluate the respondents opinion. Questionnaires were distributed among 113 respondents and 97 completely filled up questionnaires were authentic for research study. Besides primary data, secondary data were collected from manuscripts, various books, journals, articles, research papers, news papers, internet web site etc. Collected quantitative data from the respondents were analyzed using the Statistical Package for Social Science (SPSS) software. Descriptive statistics, Correlation and Regression analysis was used in this study. Following model was established for multiple regression analysis in this study.

$$CBD = \beta_0 + \beta_1 PC_1 + \beta_2 PG_2 + \beta_3 LP_3 + \beta_4 QPM_4 + \beta_5 PD_5 + \beta_6 PI_6 + E$$

Where, CBD = Consumer Buying Decision, PC₁= Packaging Color, PG₂= Packaging Graphics, LP₃= Label of Package, QPM₄= Quality of Packaging Materials, PD₅= Packaging Design and Front size style, PI₆= Printed Information of Package and E= Error term

The following hypothesis was developed for this study.



Hypothesis: 1 Packaging color has a positive impact on consumer buying decision process.

Hypothesis: 2 Packaging graphics has a positive impact on consumer buying decision process.

Hypothesis: 3 Label of package has a positive impact on consumer buying decision process.

Hypothesis: 4 Quality of packaging material has a positive impact on consumer buying decision process.

Hypothesis: 5 Package design, front size and style has a positive impact on consumer buying decision process.

Hypothesis: 6 Printed information has a positive impact on consumer buying decision process.

Table 1. shows the reliability of each construct. Reliability is usually measured by Cronbach's alpha, which shows internal consistency. Cuieford (1965) argues for a Cronbach value beyond ($\alpha = .7$) to be acceptable and reliable. Results are considered as reliable when its values are greater than 0.5.

Table 1. Reliability Analysis

Variables	Cronbach's Alpha
Consumer buying decision	0.731
Packaging color	0.756
Packaging graphics	0.622
Label of package	0.694
Quality of packaging materials	0.718
Packaging design and front size, style	0.712
Printed information of package	0.688

Source: Field survey data, August- October 2021

The Cronbach,s Alpha value of consumer buying decision is .731, packaging color is .756, packaging graphics is .622, label of package is .694, quality of packaging materials is .718, packaging design and front size, style is .712 and printed information of package is .688 respectively. It shows that all variables have the reliability in acceptable range.

RESULTS AND DISCUSSION

Table 2 portrays the descriptive statistics results (i.e. mean and standard deviation) results of the six independent variables.

Table 2. Mean and Standard Deviation Results of Independent Variables

Variables	Frequency	Mean	Std. Deviation
Packaging color	97	4.1842	.82160
Packaging graphics	97	3.7460	.72318
Label of package	97	3.8734	.93513
Quality of packaging materials	97	4.3251	.81354
Packaging design and front size, style	97	3.2156	.74351
Printed information of package	97	4.2389	.82473

Source: Field survey data, August- October 2021

The above table shows, the prime factor with the highest mean value is quality of packaging materials (mean = 4.32 and SD = 0.81), followed by printed information of package (mean = 4.23 and SD = 0.82), packaging color (mean = 4.18 SD = 0.82), label of package (mean = 3.87 SD = 0.93) and packaging graphics (mean = 3.74 SD = 0.72) respectively. One independent variable the least mean score is packaging design and front size, style (mean = 3.21 SD = 0.74).

Table 3. Pearson Correlation Result of the Variable

Variables		Decision to Buy
Packaging color	Pearson Correlation	.810**
	Sig. (2-tailed)	.000
	N	97
Packaging graphics	Pearson Correlation	.421**
	Sig. (2-tailed)	.000
	N	97
Label of package	Pearson Correlation	.689**
	Sig. (2-tailed)	.000
	N	97
Quality of packaging materials	Pearson Correlation	.784**
	Sig. (2-tailed)	.000
	N	97
Packaging design and front size, style	Pearson Correlation	.253**
	Sig. (2-tailed)	.000
	N	97
Printed information of package	Pearson Correlation	.594**
	Sig. (2-tailed)	.000
	N	97

** Correlation is significant at the 0.01 level (2-tailed)

Table 3 shows the correlation between six factors i.e. packaging color, packaging graphics, label of package, quality of packaging materials, packaging design and front size, style, printed information of package with consumer buying decision. Accordingly, all factors have a positive and significant relationship with buying decision of product. However, the degree of correlation among the factors is different with the highest correlation value of packaging color (.810) followed by quality of packaging materials (.784), label of package (.689), printed information of package (.594) and packaging graphics (.421). In contrary the least correlated factor is packaging design and front size, style (.253).

The regression equation on the above model can be presented in following way $CBD = \beta_0 + \beta_1 PC_1 + \beta_2 PG_2 + \beta_3 LP_3 + \beta_4 QPM_4 + \beta_5 PD_5 + \beta_6 PI_6 + E$. From table 4 it is found that, $F = 11.23$ and $p = .000 < 0.05$. The R Square value = .582, expressed as a percentage, it is found that 58.2% variance in consumer buying decision depends on independent variables. The regression analysis result also shows that quality of packaging materials has highest positive impact on consumer buying decision process ($\beta = .158$, $t = 4.215$, $p = 0.001 < 0.05$), followed by packaging color ($\beta = .116$, $t = 3.281$, $p = 0.000 < 0.05$), followed by printed information of package ($\beta = .224$, $t =$

Uddin *et al.* / the impact of packaging on consumer buying decision

3.211, $p=0.000 < 0.05$), followed by packaging design and front size, style ($\beta=.231$, $t= 1.633$, $p=0.011 < 0.05$), followed by label of package ($\beta=.069$, $t= 1.338$, $p=0.003 < 0.05$). Except packaging graphics all the factors have positive and significant impact on consumer buying decision process and the hypothesis is accepted.

Table 4. Coefficient of the multiple regression analysis

		Standardized Coefficients		Sig.	Result
		Beta	t		
	1(Constant)		5.239	.000	
Hypothesis 1	Packaging color	.116	3.281	.000	Accepted
Hypothesis 2	Packaging graphics	.214	0.210	.164	Rejected
Hypothesis 3	Label of package	.069	1.338	.003	Accepted
Hypothesis 4	Quality of packaging materials	.158	4.215	.001	Accepted
Hypothesis 5	Packaging design and front size, style	.231	1.633	.011	Accepted
Hypothesis 6	Printed information of package	.224	3.211	.000	Accepted
	R Square	.582			
	Adjusted R Square	.494			
	F	11.23		.000	

Dependent variable: Consumer buying decision

CONCLUSION

The present study is related to find out the impact of packaging on consumer buying decision of consumer products. In our study we have used six influential packaging factors as independent variables. According to the study results, prime factor with the highest mean value is quality of packaging materials (mean = 4.32 and SD = 0.81), followed by printed information of package and the least mean score is packaging design and front size, style (mean = 3.21 SD = 0.74). The regression analysis result also shows that quality of packaging materials has highest positive impact on consumer buying decision process ($\beta=.158$, $t= 4.215$, $p=0.001 < 0.05$), followed by packaging color, followed by printed information of package. All the factors have a positive and significant relationship with buying decision of product and the highest correlation value of packaging color (.810) followed by quality of packaging materials and other factors. So, it can be conclude that the product package is an instrument for the organizations to penetrate new and existing markets. Since packaging has become a primary vehicle for communication and branding of any product, so marketers should analyze the different needs and wants of customer and also consider the cultural differences to design the product package. However, this study opens up new horizons over potential fields of investigation which could be the subject of future research.

REFERENCES

- Adam MA. and Ali K. 2014. Impact of packaging elements of packaged milk on consumer buying behavior. *International Journal of Business and Social*, 5(1): 94-106.
- Ahmed R, Raheem AN, Vishnu P and Imam UK. 2014. Role of packaging and labeling on Pakistani consumer purchase decision. *European Scientific Journal*. 10 (16): 464 - 468.
- Alice L, 2006. The Power of packaging. United States of America. 1-29.
- Ampuero O and Vila N. 2006. Consumer perceptions of product packaging. *Journal of Consumer Marketing*. 23 (2): 100-112. <http://dx.doi.org/10.1108/07363760610655032>
- Cuieford JP. 1965. *Fundamental Statistics in Psychology and Education*. 4th edition. McGraw-Hill, New York: USA. pp.326-339.
- Kamal KS, Rehman F, Sultan F and Rashid K. 2016. Impact of Labeling and Packaging on Consumer Buying Behavior. *Journal of Marketing and Consumer Research*. 19:13 -21.
- Keller KL. 2019. *Strategic Brand Management*. New Jersey: Pearson Education. pp. 164.
- Lamb CW, Hair JF and McDaniel C. 2011. *Essentials of marketing*. 7th edition
- Likert R. 1932. A Technique for the measurement of attitudes. *Archives of Psychology*. 140: 55-60.
- Mitul MD. and Bhavesh JP. 2012. Role of Packaging on Consumer Buying Behavior. *Global Journal of Management and Business Research*. 12(10): 48-68.
- Rita K. 2009. Impact of package elements on consumer purchase. *Journal of Brand Management*. 13(2): 115-133.
- Rundh B. 2013. Linking packaging to marketing: How packaging is influencing the marketing strategy. *British Food Journal*. 115 (11): 1547- 1563. <https://doi.org/10.1108/BFJ-12-2011-0297>
- Silayoi P and Speece M. 2004. Packaging and purchase decisions: An exploratory study on the impact of involvement level and time pressure. *British Food Journal*. 106:(8) 607-628.
- Smith PR. 2004. *Packaging in marketing communications*. Kogan page limited, London: pp. 543-574.
- Underwood RL, Klein NM and Burke RB. 2001. Packaging communication: Attention effects of product imagery. *The Journal of Product and Brand Management*. 10(7): 1-19.
- Zekiri J and Hasani VV. 2015. The role and impact of the packaging effect on consumer buying behavior. *Ecoforum*. 4 (1): 232- 240.



**POVERTY AND ETHNIC MINORITY IN BANGLADESH: A SOCIOLOGICAL
INVESTIGATION ON CHAKMA COMMUNITY**

A. Mahmud and M. R. Islam*

Department of Sociology, Jagannath University, Dhaka, Bangladesh.

*Corresponding Author: Email: rafiqu1977@yahoo.com Cell Phone: +8801711038491

DOI:<https://www.doi.org/10.59125/JST.20210>

ABSTRACT

This paper attempts to depict the deteriorating socio-economic status of the indigenous community as an ethnic minority in Bangladesh. The study focuses on the poverty of the community, which is deprived by the majority of Bengalis. This is explained through a broad spectrum of issues that constructed the structure of the discrimination occurring against the community in Bangladesh. The article is based on an empirical study in Rangamati through a survey method using a structured questionnaire. The structure of poverty and its correlates thereof were explained following a systematic poverty measurement technique. The study includes measuring the Headcount ratio, Poverty gap, Squared poverty gap, and Gini- coefficient that made poverty rate and extent of poverty. The major findings reveal that the Chakma community is not only suffering from severe poverty but also faces discrimination and deprivation to a great extent. Results reveal that the Chakma community's large extent of poverty is caused by belongingness to the minority group while the group has lower inequality or Gini-coefficient among the group. Based on the findings, the study suggests specific policy guidelines for comprehensive poverty alleviation programs in order to improve the socioeconomic conditions of the indigenous community in Bangladesh.

Keywords: Chakma community, ethnicity, ethnic minority, poverty, poverty measurement minority

INTRODUCTION

Poverty is a crucial and worldwide problem that is highly recognized and mainly concentrated in South Asia and sub-Saharan African countries. These two areas contain nearly 70% of all people living in extreme poverty (Beck and Nesmith 2001). Todaro and Smith (2003) stated that the world's population increased by nearly a billion people during the period from 1987 to 1998 – from a population of just over 5 billion to just under 6 billion- and virtually all of that increase occurred in the developing world, much of that in the low-income countries where poverty is concentrated.

Bangladesh is a South Asian country with the largest number of poor just after China and India. According to BER (2007), about 40% of the total population of Bangladesh lives in extreme poverty, after ten years, the poverty rate in Bangladesh in the fiscal year 2018-19 has been 20.5 percent according to the Bangladesh Bureau of Statistics which was measured by the measurement tools using the cost of basic needs in terms of income and expenditure (Ahmed 2020). While the

poverty level has come down, income inequality has increased, as reported by the Bangladesh Bureau of Statistics (BBS)- the country's Gini coefficient stood at 0.482 in 2016, up from 0.46 in 2010 (Ahmed 2020). But the level of poverty and inequality varies according to class position, geographical position, gender, ethnicity, and minority.

Minority itself is the zone of poverty at both the international and national levels. In the United States, minorities comprise half of all poor Americans living with socioeconomic deprivation concerning education, health care insurance coverage, employment opportunity, and wage rate (Gradín 2012). That's why, Gradín (2012) mentioned that the poverty rate of the African American and Hispanic minorities as ethnic minorities in the United States stood at 24.3 and 20.8 percent respectively, both were about three times higher than the majority of Whites in 2006. These reports assure the factual relationship between the position of minorities and the economic disparity as well as poverty. Therefore, minority people are considered the poorest of the poor and the minority position is closely related to poverty and discrimination. Since minorities are subordinate social groups, their members suffer disadvantages resulting from discrimination.

Besides, minorities have non-dominant positions and majorities are dominant social groups, so the majorities can easily exclude minorities. This problem is also common in many developing countries as well as Bangladesh. In Bangladesh, there are ethnic, religious, racial, and linguistic minorities. Minorities in Bangladesh are politically oppressed and powerless, economically deprived and discriminated against, and socially depressed and excluded, which seriously affects their lives and generations. The economic situation and pattern of deprivation among ethnic minorities in Chittagong Hill Tracts (CHT), located in the south-eastern part of Bangladesh, are harsher than that of the people in the Monga-prone plain lands in the north, as per a study report in 2010 (CHT 2010). Surveyed from 1,012 households in greater Rangpur as well as *Bandarban* and *Rangamati* in 2009-10, the study conducted by the Bangladeshi Government and the United Nations released that almost 65 percent of the study population in CHT was found to live below the poverty line, compared to nearly 60 percent of plain lands 2010 (CHT 2010). Most of the non-Bengali or ethnic minorities are living in CHT which made a difference.

In short, the economic, political, social, or cultural exclusion of minorities determines a large form of poverty creating tremendous miserable conditions. With its effects, minorities suffer from educational and occupational facilities experiencing poor housing, poor health, and poor treatment. Most ethnic minorities are strongly dominated by the majority of Bengalis. In this regard, the main focus of our research is to study poverty, inequality, and deprivation of ethnic minorities in Bangladesh following empirical data and the most updated measurement scale. Since there is very limited research on poverty and relevant factors of poverty and deprivation of the Chakma community, the research requires an investigation of poverty and its correlated factors to the community. That means the research requires an empirical study that aims to measure the poverty and inequality of the Chakma community as part of the study of ethnic minorities and to assess the co-related aspects of poverty in terms of material condition, deprivation, health, and necessities of the community.

OBJECTIVES OF STUDY

The main objective of this study is to examine the extent of poverty and inequality among the members of the Chakma community in Bangladesh. In this context, the present paper highlights those socio-economic factors that represent poverty and inequality of the Chakma. The study also focuses on the co-related issues of poverty and inequality among the Chakma community in Bangladesh. To materialize the specific focuses, particularly the paper addresses following objectives and research questions:

- i. To measure the extent of poverty and inequality among the members of the Chakma community in Bangladesh
- ii. To evaluate the co-related issues of poverty and deprivation among the Chakma community in Bangladesh

MATERIALS AND METHODS

Research method and sampling

The study is based on both primary and secondary sources of information. Primary information was collected from quantitative measures of the survey method, and the secondary sources involve national and international articles, websites, and books. The Chittagong Hill Tracts (CHT) cover 10 percent of the total area of Bangladesh and are home to twelve or thirteen different indigenous peoples of which Chakma, Marma, and Tripura total approximately 90 percent; though their proportion in the population is much smaller: official figures suggest around 1.8 percent, amounting to around 1.6 million, therefore the indigenous peoples are regarded minority and Bengalis as a majority (“World Directory of Minorities” 2018). To study the poverty of minorities we have chosen the Chakma community as an ethnic minority as a field of study. The field survey was conducted in 2010 and studied the households of the Chakma community at *Bonorupa* in Rangamati. 75 respondents were selected as the sample size was randomly nominated. Respondents were selected from different professions and categories and in terms of age, priority was given to the older people who are usually the head of the households. Most of the information was found from the housewives of indigenous people. The respondents provided the approximate value of household income and expenditure on food items and non-food items such as housing, household sundries, clothing, educational utensils and medicine which are essential for daily lives and culturally determined. We tried to find out the total monthly income of households by counting not only the husband’s income but also the total income of family members. Respondents provided information on their physical as well as cultural needs and requirements adding their present condition and standard of living.

Measurement techniques and constructing poverty line

Though Rowntree’s poverty line for the measurement of absolute poverty is widely used, Sen’s poverty line is applicable here regarding the cultural standard of community practice. We have constructed a poverty line mostly based on Amartya Sen’s method¹. Based on the poverty

¹ Sen’s Poverty line is constructed by considering minimum desired needs (Food cost and non-food cost- clothing, education, medicine, bills and festival) according to market value.

measurement method and field data, we found individual income that helped to construct the poverty line and to calculate the Income Gap (income shortfall), Poverty Gap (aggregate shortfall of income of all the poor), Squared Poverty Gap (severity of poverty), and Gini-coefficient (inequality ratio) (Sen, 1982). Through the survey research, we have found the items of minimum desired needs which correspond to the socially approved practices. Their needs are divided into two parts: (i) food items (ii) Non-food items. Food items include rice, oil, pulse, vegetables, small fish, etc. and non-food items include medicine, clothing, sundries, educational sphere, and religion in a festival sphere. According to the market price of the survey period, the total account of food cost Tk 170 per day or Tk 5100 per month per household of 5 members. According to the responses of survey households of 5 members, the minimum average non-food needs including costs are measured. The total non-food costs are Tk1900 per month per household of 5 members. So, the total costs of food and non-food items are Tk 7000 per household of 5 members. Per head or individual costs (minimum) = Tk1400 = individual income = poverty line.

RESULTS AND DISCUSSION

Poverty measurement by income method

Our survey research shows that 41.3% are poor considering culturally determined absolute poverty, the inequality level below the poverty line is 19.3% and the mean income is Tk 2093 per capita per month in the community. Survey data shows the calculative form of mean, median, and standard deviation in the way that the mean household income is 8367 TK per household per month, whereas 11480 Tk is the national mean income., the median income or income of central value is Tk7428, the Average per head income is 2093 TK, the standard deviation (square root of variance) is Tk5679 and the coefficient of variation or C.V. is 67.9 percent. There is no difference in average family size in comparison with national data. Although the family size of the community is as same as the national data, the mean income and income inequality show a difference in comparison with national data.

Table 1. Index of poverty by income method

Poverty Measures	Index	Percentage
Headcount ratio	0.413	41.3
Poverty gap	0.158	16
Squared poverty gap	0.089	9
Gini coefficient	0.193	19.3

Through accounting for the Headcount ratio, Aggregate poverty gap, and Gini coefficient below the poverty line, the extent of poverty² in Chakma is 13.1%. The table shows that the headcount ratio of the Chakma community in Rangamati

² . Extent of poverty is measured by Headcount ratio, poverty gap, squared poverty gap, and Gini-coefficient. $q=31$, $n=75$, $n=\text{population}$ (q/n), $q=\text{no. of people}$; Poverty line : $z=1400$, ;

$y_i=\text{individual income}$; Poverty gap $= \frac{1}{n} \left(\frac{z - y_i}{z} \right)$; Squared poverty gap $= \frac{1}{n} \left(\frac{z - y_i}{z} \right)^2$;

Mahmud and Islam /Poverty and ethnic minority in Bangladesh

is 41.3%. Absolute poverty may be measured by the headcount ratio but this does not indicate the extent of poverty, as the headcount ratio ignores the extent of income shortfalls. Measuring the extent of poverty² requires calculating the poverty gap, squared poverty gap, and Gini-coefficient. The Table depicts a poverty gap of 16%, a squared poverty gap of 9 %, and a Gini- coefficient of 19.3%. The US Bureau of the Census (2001) reports that- 14.4% of White children lived in homes at or below the poverty line in 2000, whereas 30% percent of African American children and 29% percent of Latino children lived in families below the poverty line. This statistical report of different minority groups does not manifest the poverty gap and Gini-coefficient, thereby, the findings clarify well understanding of poverty and inequality in the community. As the Chakma community is more homogenous, within the community its income gap and level of inequality are not large enough. The extent of poverty in the community became meager at about 13 %. The data prove that the headcount ratio is more than three times higher than the extent of poverty. At the national level, 31.5 %t are poor, the inequality level is 32.1 %, mean income is Tk 2553 per capita per month according to national data. (Bangladesh bureau of statistics, 2010). The absolute poverty rate of the community (41.3 %) is higher than the national data (31.5 %). But the community's inequality level (19.3 %) is lower than the national inequality level (32.1 %). We know that the country is comprised of various classes with large class differences, so its inequality level is much higher than the Chakma community.

Poverty and its Correlates

Earnings and expenditures

According to survey data, the broad categories of occupation are official job, business, weaving, and day labor. Official jobs including clerical jobs are the highest percentage of various occupations in the community about 33.3 %. As the sample area was selected nearby a suburban area, most of the occupations belong to low-paid official jobs.

Table 2. Distribution of income sources and expenditures as correlates to poverty

Indicators	Categories	Percentage
Earning sources	Low paid jobs	33.3
	Business	21.3
	Tiny business	10.7
	Day laborers	16
	Housewives	77.3
Expenditure (monthly)	For food items	58.4
	Necessary items (non-food)	41.6
	Child education	17.5
	Clothing	7.2
	Treatment	5.1

*Gini coefficient, $G_i = \sum X_i * Y_{i+1} + \sum X_{i+1} * Y_i$; X_i = Proportion Population, I = Cumulative Income, * = Multiplied.*

The second-highest category is business including a tiny business that is 21.3 %. The third-largest type is day labor which accounts for 16% of husbands. Most of the females in the community are housewives that are 77.3 %. The data reveals that (Table 2) in the Community, 58.4 % of total expenditure is used on food items, and the rest of the expenditure is used on non-food expenditures (clothing, education, medicine, bills, sundries, festival cost). Of the non-food expenditure, a higher percentage (17.5 %) was used for educational purposes and the lowest percentage was used for treatment. It is seen that most people's earnings are so limited that they have to spend the highest percentage for their sustenance. They have to spend a limited share on child education and the worst condition is that a very poor amount has been spent on health care and treatment.

Deprivation and material condition

Spicker (2007) argues that poverty is the lack of basic security which would be possible for a poor person to be subject to multiple deprivations even though that person was not experiencing a specific deprivation at a particular point in time. However, the arising conflict between the minority and the majority population in Bangladesh causes displacement in the region which is associated with poverty and deprivation (Council, 2006).

Table 3. Distribution of deprivation and material condition as correlates to poverty

Indicators	Categories	Percentage
Deprivation sundries	There is no sofa set	49.3
	There is no cot for each adult	54.7
	There is no book self	58.7
	There is no Almirah	40
	There is no TV	37.3
	There is no Radio	93.3
	There is no Charger	52
	There is no light-fan	49.3
	There is no Gas stove	69.4
Deprivation of food and clothing	Cooking meals per day(<3times)	37.3
	Not having fish/meat most days of the week	54.7
	Babies get insufficient mother milk	25.3
	Babies do not get milk powder	52
	All members do not get a new dress	38.6
	Household members get the old dress from relatives	58.7
	Inability to provide new dress during the festival	16
Material condition of living house	Brick-built house (<i>Pacca</i>)	6.7
	Semi brick-built house (brick with tin)	33.3
	Straw-wood made house	60
	Tin made roof	72
	Straw made roof	13.3
	Damp wall	32.7
	Raw floor	42.7
	No ventilated house	82.7
	House without windows	42.7

Mahmud and Islam / Poverty and ethnic minority in Bangladesh

N.B. In 'Housing condition'- Pacca= brick built and cemented, Katcha= soil or bamboo made, Katcha floor= not brick made or not cemented; In 'Sanitation'- Pacca latrine= Brick built and cemented, Semi pacca= Brick built and cemented but the roof is tin made.

In this context, Table 3 represents the relative percentage of different household sundries that are essential for their living. The table shows that 60 % have a minimum of a piece of Almirah, 51.7 % have a minimum of a piece of a Sofa set and 45.3 percent have one cot for each adult. Households are deprived of household items such as bookshelves 58.7 %, sofa sets 49.3 %, and gas stoves 69.4 %. 37.3 % of households are also deprived of TV, whereas radio is 93.3 %, and chargers 52 %, light fans 49.3 %. Due to having cheap rate furniture and availability of wood, nearer to about 50 % have sofa set, cot, *Almira* and bookshelves. As the necessity of TV replaced the necessity of radio, the highest percentage of the deprivation of radio is insignificant. The table shows that 40 percent

of households have brick-made houses which 6.7 % are brick-built and 33.3 percent are semi-brick-built, the rest are made of wood and straw. 13.3 % of households have straw-made roofs; 72 % have tin-made roofs. 42.7 % have houses with damp walls, 82.7 % have no ventilation and 42.7 % of houses have no windows.

Table 3 depicts that the highest percentage of the community is deprived of good quality housing whereas only 6.7 % have cemented brick-made houses. The vulnerable situation can be seen clearly when we know that 33 percent of households have a damp wall and 43 % have raw or soil-made floors. According to data on food and clothing, 37.3 percent take cooking meals 2 times per day, 54.7 % take pulses-vegetables or don't have fish/meat most days of the week. That means most people cannot provide nutritious food to their families. 25.3 % of respondents say, their children get insufficient mother milk whereas 52 % of heads of households can't provide milk powder to their children. 58.7 % of households are getting old dresses from their relatives as well as 30% of heads of households cannot provide new dresses during the festival.

The data signifies the vulnerability of the Chakma people. More than 50 % of households have to depend on relatives for their clothing which implies the social exclusion of the community. The data presents the percentage of land ownership in which 20 % of indigenous have less than 1 *bigha* of land, 8% have less than 1 acre of land and 26.7 % have more than 1 acre of land. The highest number of households (45.3 percent) have no arable land. That means about 45 percent of households are deprived of agricultural products and their benefits. Around 26.7 % of households have a satisfactory amount of land so they get better benefits from land. Overall, 54.7 % of households have more or less arable land that is helpful for their livelihood and better living standard. The table shows that 20 percent of households have brick-built (paved) and semi-brick-built latrines, and 69.3 % of households have sanitary latrines made of pit and tin. Only 10.7% have unsanitary or raw latrines which are unhygienic. Overall, most of the households have a better quality of sanitation as 89.3 % have sanitary latrine although 69.3 percent of latrine is not well cemented and are brick-made. As the area is suburban, a proper drain system is essential, but most households are deprived of a drain facility.

Collected data on health and illness depicts that (Table 4), 29.3 % of households have a minimum of one infant death. Although the services and treatment facilities are not well enough, 40 % of households take treatment from Govt. hospitals, in which poverty is a major concern. 46.7 % take treatment from the clinic as they have better solvency. Generally, well-being people give priority to medical checkups in a clinic or private hospital for pregnancy treatment. Most of the poor get treatment from Govt. hospital but their facilities are not well enough. The data shows that 69.3 % of mothers did not take medical checkups in the last pregnancy. Due to the economic problem, 37.3 % of mothers did not take medical checkups. 20 percent of mothers went to the clinic for delivery but 77.3 % of mothers took delivery at home in the traditional way. 45.3 % of mothers did not take a balanced diet (egg, meat, milk, fruit, fish) during the last pregnancy. Among them, due to economic causes, 50 % of mothers did not take a balanced diet. So, the cause of the economic problem as well as cultural backwardness most of the mothers didn't take proper medical checkups and balanced diets. Overall, the rising discrimination, harassment, and segregation created little control over minority rights that enhanced huge deprivation, inequality, and poverty crisis at large in CHT areas in which indigenous ethnic minorities have lost their general human rights and right to live without discrimination.

Health condition and treatment

Table 4. Percentage distribution of the quality of treatment and health condition

Health, Illness& treatment:	Percentage
Households affected by a minimum one infant death	29.3
Households take treatment from Govt. hospital	40
Households take treatment from Clinic	46.7
Mothers had no medical checkups in the last pregnancy	69.3
Financial problems to take a medical check-up	37.3
Child delivery case in Govt. hospital	2.7
Child delivery case in the clinic	20
Delivery at home	77.3
Mothers didn't take a balanced diet in the last pregnancy	45.3
Due to the economic problem, they lacked a good diet	50

CONCLUSIONS

Findings reveal the result that 41.3 % are absolutely poor in the Chakma community which is economically measured by the headcount ratio. Also, the community has a 16 % poverty gap, a 9 % squared poverty gap, and a 19 % Gini- coefficient (Inequality among the poor). With the mathematical use of the Headcount ratio, Aggregate poverty gap, and Gini coefficient, the extent of poverty in the Chakma is 13 %. The results indicate that the poverty of this community is higher than the poverty ratio of the country while its inequality level within the community is low. It is because homogeneity in the minority has lower inequality but higher poverty. Besides, demographically, the average family size of the community is found as 4.88, which means

there is no difference in average family size in comparison with Bangladesh national data. As most households have job insecurity and limited income, a very small amount is used for education and treatment. A large extent of households has deprivation of household sundries and poor housing conditions. It remarks that the socio-economic status and poverty situation of Chakma households is in worse condition. Due to the poverty situation, a higher ratio of family members takes treatment from Govt. hospitals avoiding private hospitals. The worst situation is that two-thirds of mothers

did not take medical checkups during the last pregnancy, and due to economic problems, most of them did not take medical checkups. Also, more than two-thirds of mothers took delivery at home in a traditional way and they did not take a balanced diet during the last pregnancy. Due to its minority position, the Chakma community doesn't get the educational facility, job security, and Govt. support to enhance its income ability- the poverty situation is the fortune of the community.

Under these circumstances the study produces suggests that the government should develop a comprehensive poverty alleviation policy and plan of action at all levels. We need to undertake research and study in all areas of poverty in a specific field such as minority communities whether ethnic minority or religious minority. Govt. should construct sufficient educational organizations such as schools and colleges providing free educational services and increasing the percentage of quota in public universities for higher education. Also, there is a need to establish and develop linkages and networking, cooperation, and consultancy between Government, international agencies, and NGOs to work on the issues fruitfully. Alongside, they should be given governmental credit at the minimum interest rate for operating a small-scale business or self-employment. The government should formulate an annual budget for special measures that should be taken for vulnerable ethnic minority people.

REFERENCES

- Ahmed M. 2020. Poverty and exclusion: Education and technology to the rescue. The Daily Star. <https://www.thedailystar.net/supplements/29th-anniversary-supplements/digitisation-and-inclusivity-taking-everyone-along/news/poverty-and-exclusion-1869652>.
- Beck T and Nesmith C. 2001. Building on poor people's capacities: The case of common property resources in India and West Africa. *World Development*, 29(1):119-133. [https://doi.org/10.1016/S0305-750X\(00\)00089-9](https://doi.org/10.1016/S0305-750X(00)00089-9).
- BER. 2007. Bangladesh economic review, Finance Division, Ministry of Finance, Government of the Peoples' Republic of Bangladesh. Chittagong Hill Tracts: Ethnic Minorities the Hardest Hit by Poverty.
- Nations and Peoples Organization (UNPO). Retrieved June 28, 2020. <https://unpo.org/article/11330>.
- Council NR. 2006, March 28. Bangladesh: Minorities increasingly at risk of displacement. Internal Displacement Monitoring Center (iDMC). <https://www.internal-displacement.org/sites/default/files/publications/documents/200603-ap-bangladesh-bangladesh-minorities-increasingly-at-risk-of-displacement-country-en.pdf>.
- Gradín C. 2012. Poverty among minorities in the United States: Explaining the racial poverty gap for Blacks and Latinos. *Applied Economics*, 44(29), 3793-3804. <https://doi.org/10.1080/00036846.2011.581219>.

J. Sci. Technol. (Dinajpur) 20 (December 2022): 82-91

- Sen A. 1982. Poverty and famines: an essay on entitlement and deprivation. Oxford university press, London.
- Spicker P. 2007. Definitions of poverty: twelve clusters of meaning. Poverty: An international glossary, pp. 229-243. <http://rszarf.ips.uw.edu.pl/welfare-state/spicker.pdf>.
- Todaro MP and Smith SC. 2003. Economic Development (8th edition), England.
- U.S. Bureau of the Census. 2001. Current population survey, March 2000: Poverty in the United States. Current Population Reports, Series P.60, no. 214. Washington, DC: U.S. Government Printing Office.
- World Directory of Minorities and Indigenous Peoples - Bangladesh: Adivasis. 2018, July. Minority Rights Group International. <https://www.refworld.org/docid/49749d5841.html>



**IMPACT OF CAPITAL STRUCTURE ON BANK PERFORMANCE: A STUDY ON
JANATA BANK LIMITED OF BANGLADESH**

H. Begum*, S. Rimu and J. Ara

¹Department of Finance and Banking, Hajee Mohammad Danesh Science and Technology
University, Dinajpur, Bangladesh

*Corresponding Author: Email: humaira.begum@hstu.ac.bd; Cell Phone: +8801766397707
DOI:<https://www.doi.org/10.59125/JST.20211>

ABSTRACT

This study aims to examine the impact of capital structure on the bank performance of Janata Bank Limited (JBL) from 2011 to 2021. Furthermore, the goal of this study is to determine the connection between debt combinations and financial performance. For analysis, secondary data are mainly used from the last 11 years (2011-2021) annual reports of Janata Bank Limited. In this study capital structure measures (long-term debt on equity, long-term debt on the asset, total debt on equity, total debt on the asset, short-term debt on equity, short-term debt asset) are selected as the independent variables, and performance measures (return on asset, return on equity, return on investment) were considered as the dependent variables. As statistical tools, regression and correlation analysis have been used in this study. The study's findings demonstrated a strong correlation between JBL's capital structure and financial performance.

Keywords: Capital structure, financial performance, impact, correlation

INTRODUCTION

A significant area of study in corporate finance literature has been capital structure decision and their effects on financial performance (Chalise and Adhikari 2022). Capital structure is primarily concerned with how firm(s) chooses to divide their cash flows into two fixed components (i.e., loan capital) and a residual component (i.e., shareholders' equity). Banks and economies have benefited when capital has actually been recovered and balance sheets have been rebuilt (Pham et al. 2022). With this in mind, banks mobilize funds in the form of deposits that can later be utilized to fund various projects and to give loans in addition to financing for commercial obligations or equity shares. Only well-capitalized banks can meet the needs of the real economy to produce robust, long-term expansion claims Carney (2013). The study of (Pham et al. 2022) aims to ascertain how capital structure affects the profitability of Vietnamese commercial banks. The results of the study show that while non-deposit liabilities have a favorable impact on bank profitability, client deposits have a negative impact. Oboro and Peter (2021) investigate the effects of optimal capital structure on ten multinational companies' performance measures from 2010 to 2019. The performance of a few Iraqi private banks is examined in this study together with the impact of capital structure. Results show that return on assets (ROA) is not significantly impacted by any independent variable, whereas return on equity is positively impacted by total debt to

capital (Ibrahim 2019). (Nguyen et al. 2021) shows that the capital structure, as shown by the total debt to assets and debt to equity ratios, has a negative and significant impact on the performance of a number of commercial banks (measured by ROA and ROE). Although some of them (El-Chaarani and El-Abiadn 2019) demonstrated their significant link, the findings were not conclusive. (Zahid et al. 2022) used a sample of 24 Bangladeshi banks from 2010 to 2017 and concentrated on both conventional and Islamic banks. The study's findings showed a substantial positive correlation between loans and assets and a strong negative correlation between GDP and ROE. Additionally, it showed that loan to asset ratios had a favorable and significant impact on ROA and ROE. Using panel data from 2009 to 2016, Sarker and Islam (2021) conducted a study, and the results showed a negative correlation between capital structure profitability. The profitability of the banks and their expansion were positively correlated. Saeed et al. (2013) discovered, on the other hand, that capital structure has a favorable effect on bank performance. The results of a multiple regression model suggested that capital structure ratios—including long-term debt to capital, short-term debt to capital, and total debt to capital—were positively correlated with bank performance when used to measure the performance of Pakistani banks listed on the Karachi Stock Exchange from 2007 to 2011. Long-term debt has a beneficial impact on performance in terms of ROA and ROE, according to Molla (2020) analysis of panel data for the years 2014 to 2018. The capital structure has no discernible effect on the performance of the bank in terms of ROA, ROE, and EPS. Oyedokun et al. (2018) contend that the capital structure has both a major and insignificant impact on performance-related factors, and they advise businesses to adopt a balanced capital structure strategy to raise their firm's value. Several works have been carried out on this area in Bangladesh whereas no one entirely focuses on debt and equity combination in connection with performance of JBL. To cover this gap this study, consider the important and coherent debt and equity ratios as well to measure the impact of those on the performance of JBL. Therefore, this study targets to examine the effect of capital structure on bank performance. Furthermore, this study will assess the association between capital structure and bank performance of JBL.

MATERIAL AND METHODS

Data: This study used secondary data from financial statements for the period 11 years from 2011 to 2021 of Janata Bank Limited. The secondary data were collected from annual reports, institutions websites and the central bank of Bangladesh.

Analytical tools

In this study, researchers used correlation and regression. SPSS (Statistical Package for the Social Sciences) has been used to analyze the data.

Model specification

In this study the following regression models have been used:

$$ROE = \alpha_0 + \alpha_1(TD/EQ) + \alpha_2(LD/EQ) + \alpha_3(SD/EQ) + \alpha_4(TD/AST) + \alpha_5(LD/AST) + \alpha_6(SD/AST) + \varepsilon$$

$$ROA = \lambda_0 + \lambda_1(TD/EQ) + \lambda_2(LD/EQ) + \lambda_3(SD/EQ) + \lambda_4(TD/AST) + \lambda_5(LD/AST) + \lambda_6(SD/AST) + \varepsilon$$

$$ROI = \beta_0 + \beta_1(TD/EQ) + \beta_2(LD/EQ) + \beta_3(SD/EQ) + \beta_4(TD/AST) + \beta_5(LD/AST) + \beta_6(SD/AST) + \varepsilon$$

Where,

ROE: Return on equity	LD/ AST: Long term debt to total asset ratio
ROA: Return on Asset	SD/AST: Short term asset to total asset ratio
ROI: Return on Investment	$\alpha_0, \lambda_0, \beta_0$: Intercept terms
TD/EQ: Total debt to equity ratio	$\alpha_1, \alpha_2, \dots, \alpha_6$: Regression co-efficient
LD/EQ: Tong term debt to equity ratio	$\lambda_0, \lambda_1, \dots, \lambda_6$: Regression co-efficient
SD/EQ: Short term debt to equity ratio	$\beta_0, \beta_1, \dots, \beta_6$: Regression co-efficien
TD/AST: Total debt to total asset ratio	

Table 1. Variables list

Determinations	Variables	Notations
Dependent Variables	Return on Asset	ROA
	Return on Equity	ROE
	Return On Investment	ROI
Independent variables	Long term debt on equity	LD/EQ
	Long term debt on Asset	LD/AST
	Total Debt On equity	TD/EQ
	Total debt on asset	TD/AST
	Short term debt on equity	SD/EQ
	Short term debt on Asset	SD/AST

Proposed Hypotheses

H1: LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST have a significant impact on ROA.

H2: LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST have a significant impact on ROE.

H3: LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST have a significant impact on ROI.

Test of multicollinearity

Multicollinearity is a serious problem for analyzing relationship-based data. It may be appeared due to several reasons such as data collection problem, constraints in the model or over determined model and so on (Mansfield and Helms, 1982; Alin, 2010 and Daoud, 2017). Variance Inflation Factor (VIF) is a common tool to measure and quantify the nature of variance inflation as well as the multicollinearity. VIF is estimated as

$$VIF = \frac{1}{1 - R^2}$$

Where, R^2 is the unadjusted coefficient of determination for regressing the i th explanatory variable on the remaining ones.

RESULT AND DISCUSSION

Table 2. Descriptive Statistics

	Descriptive Statistics							
			Std.					
	Minimum	Maximum	Mean	Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
ROA	-0.035	0.014	0.001	0.0123	-2.532	0.661	7.666	1.279
ROE	-0.497	0.301	0.035	0.195	-2.122	0.661	6.603	1.279
ROI	0.058	0.094	0.078	0.011	-0.348	0.661	-0.997	1.279
TD/EQ	10.480	25.350	15.749	5.163	0.977	0.661	-0.192	1.279
LD/EQ	0.063	0.163	0.134	0.030	-1.474	0.661	1.935	1.279
SD/EQ	1.450	5.840	2.506	1.277	2.007	0.661	4.610	1.279
TD/AST	2.090	4.690	3.190	0.781	0.320	0.661	-0.245	1.279
LD/AST	0.063	0.162	0.134	0.030	-1.532	0.661	2.110	1.279
SD/AST	1.440	5.840	2.530	1.267	1.984	0.661	4.670	1.279
SD/AST	1.440	5.840	2.530	1.267	1.984	0.661	4.670	1.279

Table 2 presents a summary of descriptive statistics of the dependent and independent variables used in the study. Descriptive statistics show mean, minimum, maximum, standard deviation, skewness and kurtosis. Mean of ROA, ROE, ROI are (0.001, 0.035, 0.078) respectively. The mean value of capital structures (LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST) are about 0.134, 0.134, 15.749, 3.190, 2.506, 2.530), which indicates Janata Bank finance their asset by an average use of the long-term debt and short-term debt.

Table 3 shows that ROA is positively significant at 0.01 level with ROE, LD/EQ and LD/AST. On the other hand, TD/EQ, SD/EQ and SD/AST is significantly negative at 0.05 level. Whereas, ROE is positively significant at 0.05 level with LD/EQ and at 0.01 level with LD/AST. Furthermore, ROE is significantly negative at 0.01 level with TD/EQ, SD/EQ and SD/AST. While LD/EQ is significantly positive association with LD/AST and signification negative association with TD/EQ. Meanwhile, LD/AST is significantly negative association with only TD/EQ at 0.01 level.

Table 3. Correlation Analysis

	Correlations								
	ROA	ROE	ROI	LD/EQ	LD/AST	TD/EQ	TD/AST	SD/EQ	SD/AST
ROA	1								
ROE	.989**	1							
ROI	0.077	0.103	1						
LD/EQ	.789**	.731*	-0.052	1					
LD/AST	.794**	.738**	-0.046	1.000**	1				
TD/EQ	-.661*	-.618*	-0.181	-.902**	-.901**	1			
TD/AST	0.093	0.089	0.015	0.279	0.272	-0.570	1		
SD/EQ	-.670*	-.637*	0.195	-0.557	-0.565	0.193	0.558	1	
SD/AST	-.668*	-.637*	0.220	-0.539	-0.548	0.171	0.551	.996**	1

** . Correlation is significant at the 0.01 level (2-tailed).
 * . Correlation is significant at the 0.05 level (2-tailed).

Interpretation of first model

Table 4. Impact of LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST on ROA

	Coefficient	T	P	Sig	VIF	1/VIF
Constant	0.197	1.169	.307	.307	2.495	0.401
LD/EQ	2.605	.483	.645	.645	1.814	0.551
LD/AST	-3.433	-.580	.593	.593	1.423	0.703
TD/EQ	-.004	-1.279	.270	.270	1.406	0.711
TD/AST	0.009	1.032	.360	.360	1.276	0.783
SD/EQ	-.004	-.147	.690	.690	1.683	0.594
SD/AST	-.013	-.454	.673	.673	1.567	0.638
R square		.842				
Adj R square		.605				
F		3.553				
Durbin Watson		2.115				

Table 4 shows that R square indicates that 84% of ROA can be explained by the differences in independent variables and the remainder 26% of ROA is attributed to other factors. It also represents that at the 5% level of significance, F- value is 3.553 and p values (0.307, 0.645, 0.593, 0.270, 0.360, 0.690 and 0.673) are greater than 0.005, which indicated that the explanatory variables (LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST) have no significant impact on ROA.

Interpretation of second model

Table 4 shows that R square indicates that 77% of ROE can be explained by the differences in independent variables and the remainder 23% of ROE is attributed to other factors. It also represents that at the 5% level of significance, F- value is 2.342 and p values (0.439, 0.969, 0.893,

0.399, 0.381, 0.835, and 0.809) are greater than 0.005, which indicated that the explanatory variables (LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST) have no significant impact on ROE.

Table 4. Impact of LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST on ROE

	Coefficient	T	P	Sig	VIF	1/VIF
Constant	2.603	.858	.439	.439	1.495	0.669
LD/EQ	4.004	.041	.969	.969	1.514	0.661
LD/AST	-15.220	-.143	.893	.893	1.683	0.594
TD/EQ	-.058	-.944	.399	.399	1.506	0.664
TD/AST	.152	.983	.381	.381	1.276	0.784
SD/EQ	-.118	-.223	.835	.835	1.789	0.559
SD/AST	-.137	-.259	.809	.809	1.678	0.596
R square		.773				
Adj R ²		.446				
F		2.342				
Durbin Watson		2.504				

Interpretation of third model

Table 5. Impact of LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST on ROI

	Coefficient	T	P	Sig.	VIF	1/VIF
Constant	.433	1.905	.129	.129	2.224	0.449
LDE	1.165	.160	.881	.881	1.567	0.638
LDA	-2.496	-.312	.770	.770	1.345	0.734
TDE	-.008	1.755	.154	.154	1.467	0.682
TDA	-.011	-.960	.391	.391	1.987	0.503
SDE	-.00-1	-.027	.940	.940	1.889	0.529
SDA	.005	-.124	.907	.907	1.689	0.592
R square		.639				
Adj R ²		.098				
F		1.181				
Durbin Watson		2.077				

Table 5 shows that R square indicates that 64% of ROI can be explained by the differences in independent variables and the remainder 36% of ROI is attributed to other factors. It also represents that at the 5% level of significance, F- value is 2.342 and p values (0.129, 0.881, 0.770, 0.154, 0.391, 0.940, and 0.907) are greater than 0.005, which indicated that the explanatory variables (LD/EQ, LD/AST, TD/EQ, TD/AST, SD/EQ and SD/AST) have no significant impact on ROI.

Table 6. Hypothesis testing result

Hypothesis	Tool	Explanation	Result
H1: LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST have a significant impact on ROA.	Regression	Model 1 represents that R square is 0.842 or 8.42%. Durbin-Watson value is 2.115 which indicate negative autocorrelation. At 10% significance level LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST represents insignificant negative relation with ROA. The hypothesis testing shows insignificant negative result.	Rejected
H2: LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST have a significant impact on ROE.	Regression	Model 2 represents that R square is 0.773 or 7.73%. Durbin-Watson value is 2.504 which indicate negative autocorrelation. At 10% significance level LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST represents insignificant negative relation with ROA.	Rejected
H3: LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST have a significant impact on ROI.	Regression	Model 3 represents that R square is 0.639 or 6.39%. Durbin-Watson value is 2.077 which indicate negative autocorrelation. At 10% significance level LD/EQ, LD/ AST, TD/EQ, TD/AST, SD/EQ and SD/AST represents insignificant negative relation with ROA. The hypothesis testing shows insignificant negative result.	Rejected

CONCLUSION

Comparing commercial banks to nonbanks, commercial banks are often distinguished by having high debt to total assets and debt to equity ratios, with customer deposits serving as their primary source of debt. Whereas the capital structure significantly and negatively affects the performance of the firm as a whole. This study shows the relationship between performance along with different combination of debt levels. The findings demonstrate a substantial positive correlation between total debt to equity ratio, long-term debt to equity ratio, and short-term debt to asset ratio and a significant negative correlation between total debt to asset ratio, long-term debt to asset

ratio, and return on asset. The findings of the study led to the conclusion that the factors and indicators used to measure capital structure and performance determine the impact of capital structure on firm performance. When capital structure was assessed using the debt-to-equity ratio and performance was assessed using return on asset, return on equity, and return on investment, the study's findings suggested that there was a tradeoff between the usage of debts and firm performance. The study also comes to the conclusion that though people choose to employ short-term debts like deposits rather than commercial debts, they still have a chance to succeed because the debt-to-asset ratio was found to significantly improve return on equity. A key policy implication of this study is that, particularly in the case of emerging nations like Bangladesh, a well-balanced and practically usable capital structure is necessary to improve bank performance or profitability. Also, a future study that focuses on other industries, such as financial institutions, will be conducted in order to compare the performance of commercial banks and financial institutions. Additionally, by using the commercial banks of other countries as a sample, this study can be expanded.

REFERENCES

- Chalise DR and Adhikari NR. 2022. The Impact of Capital Structure and Firm Size on Financial Performance of Commercial Banks in Nepal. *The EFFORTS, Journal of Education and Research*. 4(1): 102–111. <https://doi.org/10.3126/ejer.v4i1.44175>
- El-Chaarani H and El-Abiad Z. 2019. Analysis of Capital Structure and Performance of Banking Sector in Middle East Countries. *International Journal of Economics and Financial Issues, Econjournals*. 9(10): 1-11.
- Ibrahim SS. 2019. Impacts of Capital Structure on Bank Performance. *Koya University Journal of Humanities and Social Sciences*. 2(1): 118–123. <https://doi.org/10.14500/kujhss.v2n1y2019.pp118-123>
- Molla MI. 2020. Capital Structure and Bank Performance: Empirical Evidence from Bangladesh. *Asian Journal of Finance & Accounting*. 12(1): 161. <https://doi.org/10.5296/ajfa.v12i1.17014>
- Nguyen TD, Dinh TT, Vu KL and Nguyen TT. 2021. The impact of capital structure on bank performance: GMM estimation for the case of Vietnam. *Pressacademia*. 13(1): 73–83. <https://doi.org/10.17261/pressacademia.2021.1426>
- Oboro GO and Peter SA. 2021. Capital Structure Optimality and Performance Metrics of Selected Multinationals in Nigeria. *European Journal of Business and Innovation Research*. 9(1): 68–80.
- Oyedokun GE, Olatuji KA and Sanyaolu WA. 2018. Capital Structure and Firm Financial Performance. *Accounting & Taxation Review*. 2(1): 56-71.
- Pham NH., Hoang TM. and Pham NTH. 2022. The impact of capital structure on bank profitability: evidence from Vietnam. *Cogent Business and Management*. 9(1). <https://doi.org/10.1080/23311975.2022.2096263>
- Sarker N and Islam R. 2021. Issues on Bank's Capital Structure and Profitability: A Developing Country Context. *International Journal of Economics and Business Administration*. IX(1):86–104. <https://doi.org/10.35808/ijeba/660>
- Zahid A. 2022. Impacts of Capital Structure on Performance of commercial banks of Bangladesh. *International Journal of Research and Innovation in Social Science (IJRISS)*. 539-544.

JOURNAL OF SCIENCE AND TECHNOLOGY

Web: www.hstu.ac.bd

Vol. 20, No-2, (December 2022)

CONTENTS

Research articles	Page No.
<i>Agricultural Sciences</i>	
FOLIAR APPLICATION OF POTASSIUM AND GIBBERELIC ACID (GA ₃) TO ALLEVIATE DROUGHT STRESS IN WHEAT M.N. Haque, S.K. Pramanik, M.A. Hasan M.R. Islam and S. Sikder	1-10
STUDY ON GROWTH AND YIELD OF OYSTER MUSHROOM AS INFLUENCED BY COMPOSTED SAWDUST BASED SUBSTRATES N. J. Nishi, M. H. Akand, A. J. Kakon and M. H. Rahman	11-19
EFFECT OF IRRIGATION FREQUENCY ON GROWTH AND YIELD OF SOYBEAN B. Sinha, M. Fahmida and M. S. Rahman	20-29
EFFECT OF SMOKING AS POST-HARVEST TREATMENT ON THE RIPENING AND QUALITY OF BANANA (<i>Musa</i> sp) M. H. Rahman, M. T. Aktar, M. A. Kabir, M. H. Rahman and M. T. Abedin	30-36
<i>Computer Science and Engineering</i>	
PERFORMANCE STUDY OF A WALKING TYPE 4-ROW MECHANICAL RICE TRANSPLANTER M. Fahmida, U. Habiba, M. S. Rahman and Milufarzana	37-47
DESIGN DEVELOPMENT AND PERFORMANCE EVALUATION OF SOLAR POWERED SPRAYER WITH WATER LEVEL INDICATOR S. Banu, Milufarzana, M. M. Haque, M. S. Islam and S. R. Roy	48-59
<i>Business Studies and Social Sciences</i>	
IMPACT OF FACTORS AFFECTING CUSTOMER SATISFACTION TOWARDS CORPORATE LOAN IN THE BANKING SECTOR OF BANGLADESH H. Begum, S. A. Khan and M. Aktar	60-67
INVESTIGATING THE IMPACT OF SERVICE DIMENSIONS ON CUSTOMER SATISFACTION AND CUSTOMER LOYALTY: A CONTEXT ON EMERGING SERVICE ECONOMY T. Islam, S. N. Habib, R. Islam, and R. Sharmin	68-75
THE IMPACT OF PACKAGING ON CONSUMER BUYING DECISION: AN APPLICATION ON CONSUMER GOODS M. J. Uddin, H. Begum and M.A. Rouf	76-81
POVERTY AND ETHNIC MINORITY IN BANGLADESH: A SOCIOLOGICAL INVESTIGATION ON CHAKMA COMMUNITY A. Mahmud and M. R. Islam	82-91
IMPACT OF CAPITAL STRUCTURE ON BANK PERFORMANCE: A STUDY ON JANATA BANK LIMITED OF BANGLADESH H. Begum*, S. Rimu and J. Ara	92-99