BUSITEMA UNIVERSITY
Pursuing Excellence

DEPARTMENT OF AGRICULTURAL MECHANIZATION AND IRRIGATION ENGINEERING

EVALUATING ON-FARM WATER PRODUCTIVITY OF FURROW, BASIN AND HOSEPIPE IRRIGATION METHODS IN TOMATO PRODUCTION UNDER SUPPLEMENTARY IRRIGATION

CASE STUDY: KABOS, SERERE DISTRICT, UGANDA

BY

GASHALI TOM

BU/GS16/MID/3

Research Report Submitted to the Department of Agricultural Mechanization and Irrigation Engineering in Partial Fulfillment of the Requirements for the Award of Master of Science in Irrigation and Drainage Engineering of Busitema University.

July 2018

SUPERVISORS:

Dr. TWAIBU SEMWOGERERE

Dr. DAVID MAGUMBA

ABSTRACT

The research was carried out on evaluation of on-farm water productivity in tomato production using surface and overhead Irrigation techniques at Kabos Horticulture and Irrigation site in Serere district, Eastern Uganda. The aim of this study was to Evaluate On-Farm Water Productivity of Tomato Crop under Furrow, Basin and Hosepipe Irrigation Techniques. Soil samples from the study area revealed two predominant soil textural classes, i.e Clay loam and clay with field capacity ranging from 30% to 40% and low average permanent wilting point. Crop and soil data were fed into CROPWAT model to determine the crop water requirement. Irrigation scheduling revealed a relationship that Irrigation water need is inversely proportional to precipitation received. It was also clearly observed that Irrigation water decreases towards the growing season attributed to low water demand by crops due to maturity. Plant growth was monitored at 20DAT, 40DAT and 70DAT (DAT -days after transplanting). Plants under treatment 1 and 2 (flat fields) had better mean growth height compared to others due to easy drainage and good soil aeration. Statistical data analysis was completed by Excel and GENSTAT for a Randomized Complete Block Design (RCBD). Here, Marketable yield reduces with poor water management practices seen at treatment 6 and 5 where surface ponding instigated disease, root damage and fruit rotting. Basin High had the least Marketable water productivity of 1.2291 Kg/m^3 whereas Water productivity was highest (2.07 Kg/m^3) in Furrow Irrigation Treatments. Analysis of variance on water productivity revealed that Fcal < Ftab at α =0.05 and 0.01, an indication that the experiment failed to reject the null hypothesis that "Irrigation method does not improve on-farm water productivity of tomato crop". This research supports the UN Sustainable Development Goal 6 - ensuring water availability, sustainability in management and sanitation for all. The findings in this research can help alleviate the pressure being imposed on global water for agriculture, animal and industrial uses.

Key Words: *Irrigation, Crop water requirement, CROPWAT, Marketable yield, Water productivity*

DECLARATION

I, **GASHALI TOM,** declare that this research is my original work and has not been submitted for any award to any other Institution or University before. Any other author's work that was used in creating an establishment for the study reported in this thesis has been duly acknowledged.

Signed: ....

Date: 5th/9/2018 ....

APPROVAL

The thesis is submitted with approval of the following supervisors:

DR. TWAIBU SEMWOGERERE Senior Lecturer, Faculty of Engineering, Busitema University

Sign: .... Date: ...18/09/2018...

DR. DAVID MAGUMBA Lecturer, Faculty of Agriculture and Animal Sciences, Busitema University

Sign: .... Date: ...18/9/2018...

ACKNOWLEDGEMENTS

First and foremost I am very grateful to the Almighty God for the far He has brought me in both the academic journey and life outside academics.

I am so much grateful to Busitema University for the offer of research fund under the RUFORUM scheme without which it wouldn't have been possible for me to undertake this research.

I further thank the Directorate of Graduate Studies, Research and Innovations (DGRI), the Academic Registrar's department, the Faculty of Engineering and the department of Agricultural Mechanization and Irrigation Engineering (AMI) for the sufficient arrangements made for the implementation of this programme.

Special thanks also go to DR.TWAIBU SEMWOGERERE and DR. DAVID MAGUMBA; my advisors, for their invaluable advice and guidance during this research.

I owe special gratitude to my lecturers Eng. Badaza Muhammed, Mr. Okiria Martin, Dr. Jiro (JICA), Associate Prof Ochwo V. Akangah and Madam Marion Engole whose contributions were invaluable in inspiring me while pursuing the course.

I cannot forget to appreciate Mr. Kavuma Chris, Mr. Ebic Andrew and Mr. Okeetcho Yoronimo, both of AMI department of Busitema University without whom it would have been so difficult for me to reach this far in this research.

I would also like to express my heartfelt gratitude to Horticulture Irrigation Project (HIP), for the gainful engagement and technical support and exposure offered to me as a research assistant during the course of this programme.

I am very thankful to my research assistants; OthienoBoers, Obina Patrick and Gorden Nuwamanya for the tireless efforts in monitoring and collecting crop data.

Last but not least, I thank all my colleagues; the workmates and the fellow graduate students for the support and guidance accorded to me during the pursuance of this programme. Without Adong Leo Awor, I would have not pushed this course to completion.

DEDICATION

This work is dedicated to all current and up-coming students and entire stakeholders of Divine College, Buyaga and my wife Namutosi Fatuma.

TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
CWP	Crop Water Productivity
CWPF	Crop Water Production Function
DAT	Days after transplanting
DI	Deficit Irrigation
ET	Evapotranspiration
Eta	Actual evapotranspiration
ETc	Crop evapotranspiration
ET_{crop}	Crop Evapotranspiration
ETo	Reference Evapotranspiration
ETrel	Relative Evapotranspiration
EWP	Economic Water Productivity
FAO	Food and Agriculture Organization
FC	Field Capacity
GIR	Gross Irrigation Required
MAD	Maximum Allowable Deficit
MSWD	Maximum Soil Water Deficit
MSWS	Maximum Soil Water Storage
NIR	Net Irrigation Water Requirement
OMC	Organic Matter Content
PWP	Permanent Wilting Point
RCBD	Randomized Complete Block Design
SI	Supplemental Irrigation
t/ha	tone per hectare
TAW	Total Available Water
TWU	Total Water Use
WP	Water Productivity
WUE	Water Use Efficiency
WUI	Water Use Index

CHAPTER ONE: INTRODUCTION

1.1 Background

Tomato (Lycopersicon esculentum Mill) is one of the most important and has the highest acreage of any vegetable crop in the world (Jensen et al., 2010). In 2010, its global production was approximately 145.6 million tons of fresh fruit. (Matos et al., 2012). Global production levels of vegetables tomatoes inclusive increased by 55% between 1993 and 2003 (Robinah Sonko et el., January 2005), the majority of this increase coming from area expansion. Growth in productivity (yields per unit area) is limited with approximately 0.5% annually. In Uganda total vegetable production increased with 23% to a total of 556,000 Mt in 2003. Given the area increase of 30% a logical conclusion is that overall productivity of vegetable production declined.

Water resources are essential for human existence as well as for agricultural Irrigation. It is widely acknowledged that irrigated agriculture uses almost 70% of the global freshwater. In many developing countries, growing demand for Irrigation, as well as increased population and limited management are placing increasing pressure on water resources. To maintain sustainable water use in agriculture and ensure food security, a substantial improvement in agriculture Water Productivity is required (Fish man R. *et al*, 2015).The increasing worldwide shortages of water and costs of Irrigation are leading to an emphasis on developing methods of Irrigation that minimize water use (maximize the Water Productivity) (Hamlyn G. Jones, 2004)

The Water Productivity term plays a crucial role in modern agriculture which aims to increase yield production per unit of water used, both under rainfed and irrigated conditions. This can be achieved either by; increasing the Marketable yield of the crops for each unit of water transpired, reducing the outflows/ losses, or enhancing the effective use of rainfall, of the water stored in the soil, and of the marginal quality water (Ragab Ragab, 2014).Helen Fairweather of Irrigation Insights Volume 5, advanced that improving the efficiency and effectiveness of water use can result from better managing a number of factors, including water availability, fertility, pests and diseases, crop or pasture variety, planting date, soil water conditions at planting .plant density and row spacing. This means that improving water productivity requires an understanding of the whole system and should not focus solely on the application of water. Based on the above, this study evaluated the growth and yield of tomato crop, under different Irrigation methods in Kabos, Serere district in eastern Uganda.

REFERENCES

Ali MH, Talukder MSU. 2008. Increasing water productivity in crop production—A synthesis. *Agricultural Water* Management95: 1201-1213.

Allen, R.G., L.S. Pereira, D. Raes and M. Smith, 1998. Crop Evapotranspiration Guidelines

Araya, A., L. Stroosnijder, G. Girmay and S.D. Keesstra, 2011. Crop coefficient, yield

Athar, H.R. and M. Ashraf, 2005. Photosynthesis under drought stress. pp. 795-810. In: M.

Behera, S.K. and R.K. Panda, 2009. Integrated management of Irrigation water and fertilizer

Bloem S, and Mizell, R.F. 2000, integrated pest management and Florida tomatoes: a success story in progress Cooperative Extension Service, University of Florida, USA

Bras, R.L., Corodova, J.R., 1981. Intra-seasonal water allocation in deficit Irrigation. *Water*

Department of Agriculture, forestry & fisheries, Republic of South Africa. Production guidelines for Tomato.

Doorenbos, J. and A.H. Kassam, 1979. Yield response to water. FAO Irrigation and Drainage

Douglas C. Montgomery, Applied statistics and probability for engineers. —3rd ed. p. cm. ISBN 0-471-20454-4 (acid-free paper) Runger, George C. II. Title. QA276.12.M645 2002 519.5—dc21 2002016765

Economic Benefit Associated with Deficit Irrigation Scheduling in Maize. pp. 17-27.

Engindeniz, S. (2006), Economic analysis of pesticide use on processing tomato growing: a case study for Turkey Crop Protection, Vol 25, No 6, pp 534–541.

English, M., 1990. Deficit Irrigation. In Analytical framework. Irrig. and Drain. E.

FAO (Food and Agriculture Organization), 1997. Irrigation Potential in Africa: A Basin Approach: Land and Water Bulletin 4. FAO, Rome.

FAO (Food and Agriculture Organization), 2002a. Deficit Irrigationpractices. Water report No. 22.

FAO (Food and Agriculture Organization), 2002b. FAO Production Yearbook. 56: 83.

FAO (Food and Agriculture Organization), 2009. How to Feed the World in 2050. For Calculating Crop Water Requirements.

FAO Irrigation and Drainage Paper 56. FAO, for wheat crop using field experiment and simulation modeling: *Agri. water Manage.* 96:

Geerts, S. and D. Raes, 2009. Deficit Irrigation as an on-farm strategy to maximize crop water.

Geerts, S., D. Raes, M. Garcia, J. Vacher, R.J. Mamani, R. Mendoza, B. Huanca, R. Morales, Harron, W. R. A., WBesrEn, G. R. eNo CernNs, R. R. 1983. Relationship between exchangeable sodium and sodium adsorption ratio in a Solonetzic soil association. Can. J. Soil Sci. 63: 461-467.

http://api.ning.com/files/mK50tPAXydUVCJpTJkkZADatKas*tyNopa1JWCuGD4laYirgeMTUnxSjc3tMT1HNgjkalVeBEluOO*3hif6whxv*gBZlapJY/KennedySsejjembaValuChainAnalysisFreshTomatosinUgandaKenya.pdf [25June 2014].

http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/pdf. (Accessed on January https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/

Huang, M., L. Zhong and J. Gallichand, 2002. Irrigation treatments for corn with limited water supply in the Loess Plateau, China. *Canadian Biosystems Engineering*. 44 (1):

J. Cusicanqui and C. Taboada, 2008. Introducing deficit Irrigation to stabilize yields of quinoa

James et al., 1982. D.W. James, R.J. Hanks, J.J. Jurinak (Eds.), Modern Irrigated Soils, John Wiley & Sons, New York (1982), p. 235. MacNeal et al., 1970.

Jensen, C.R.; Battilani, A.; Plauborg, F.; Psarras, G.; Chartzoulakis, K.; Janowiak, F.; Stikic, R.; Jovanovic, Z.; Li, G.; Qi, X.; Liu, F.; Jacobsen, S.; Andersen, M. N. Deficit irrigation based on drought tolerance and root signalling in potatoes and tomatoes. Agricultural Water Management, v.98, p.403-413, 2010

Kennedy, 2008. Value chain analysis of fresh tomatoes in Uganda and Kenya. FAO production year book.

Kwacha A. Gomez 1988. Statistical Procedures for Agricultural Research second edition. A Wiley-intersclence Publication *Manage*. 98: 775–783.

L. Tollefson · Mohamed Abdelmoneim Wahba · John Harrington, 2016 of Horticulture Research and Development Centre, Saint-Jean-sur-Richelieu with expertise in Soil Science, https://www.researchgate.net/profile/L_TollefsonL. Tollefson on ResearchGate, the professional network for scientists. ... Allan J Cessna ... Mar 2016.

M.C.J, R. H. Bosma and J.A.J Verreth. 2006, Water for Food Water for Life: A Comprehensive Assessment of Water use

M.M. Al-Kaisi and I. Broner* (3/13). Quick Facts... Water stress during critical growth periods reduces yield and quality of crops.extension.colostate.edu/topic-areas/.../crop-water-use-and-growth-stages-4-715

Marie-Hélène Bernier, Chandra A. Madramootoo, Bano B. Mehdi, and Apurva Gollamudi, 2007.Assessing On-Farm IrrigationWater Productivity in Southern Ontario.

Matos, E. S.; Shirahige, F. H.; Melo, P. C. T. Desempenho de híbridos de tomate de crescimento indeterminado em função de sistemas de condução de plantas. Horticultura Brasileira, v.30, p.240-245, 2012.

MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY AND FISHERIES (MAAIF) AND MINISTRY OF WATER AND ENVIRONMENT NATIONAL IRRIGATION POLICY Agricultural Transformation Through Irrigation Development Ministry of Agriculture, Animal Industry and Fisheries Plot 14-18 Lugard Avenue, Entebbe P. O Box 102 Entebbe Uganda Ministry of Water and Environment Plot 22/28 Port Bell Road Luzira P. O Box 20026 Kampala Uganda NOVEMBER 2017

Mohammed Karrou, Theib Oweis, Rashad Abou El Enein and Mohamed Sherif 2012. Yield and water productivity of maize and wheat under deficit and raised bed Irrigation practices in Egypt.

Pessarakli (Ed.). Hand Book Photosynthesis, 2nd edition, CRC Press, New York, USA.

Prakash Babu Adhikar 2012 - Yield and fruit quality of tomato (Lycopersicon esculentum Mill ..., Volume 53, Issue 2, pp 102–107

Proceedings of the East Africa Integrated River Basin Management Conference Sokoine University of Agriculture, Morogoro, Tanzania.

Productivity in dry areas. *Agri. water Manage*. 96: 1275–1284. *Resour. Res.* 17 (4), 886–874. Response to water stress and water productivity of teff (*Eragrostis tef* Zucc.). Rome,

Ragab Ragab – WP3 - W4C, 2014, A note of Water use efficiency and water productivity

Rao, A.V., Z. Waseem, and S. Agarwal. 1998. Lycopene content of tomatoes and tomato products and their contribution to dietary lycopene. Food Res. Int. 31(10):737-741.

Rashidi, M. and M. Gholami, 2008. Review of crop water productivity values for tomato, potato, melon, watermelon and cantaloupe in Iran. Int. J. Agri. Biol., 10: 432–6 INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY ISSN Print: 1560–8530; ISSN Online: 1814–9596 08–004/MFA/2008/10–4–432–436 http://www.fspublishers.org Full Length Article †Department of Agricultural Machinery, Faculty of Agriculture, Islamic Azad University, Takestan Branch, Iran 1 Corresponding author's e-mail: majidrashidi81@yahoo.com; m.rashidi@aeri.ir

Robinah Sonko, Makerere University, Evelyn Njue, ETC – East Africa , James M. Ssebuliba, Makerere University, Andre de Jager, Wageningen University and Research Center, The horticultural sector in Uganda, January, 2015

Sadras VO, Grassini P, Steduto P. 2011. Status of water use efficiency of main crops.*SOLAW Background Thematic Report - TR07*. FAO, Rome, 41pp.

Stephanus Malherbe and Diana Marais, 2015. Economics, yield, and ecology: A case study from the South African tomato industry.

Tusiime, Sharon Mbabazi, "Evaluating horticultural practices for sustainable tomato production in Kamuli, Uganda" (2014).Graduate Theses and Dissertations. 14033.https://lib.dr.iastate.edu/etd/14033

Uganda's second Draft National Irrigation Master Plan (2010-2035).

Water conservation factsheet, ministry of agriculture, British Columbia, June 2015 order number 619.000-1, Agdex 550

www.apal.com.au/Service-guide Apal Agricultural Laboratory Soil Test Interpretation Guide, APALs soil reports

www.naturalresources.sa.gov.au/.../irrigation/water-use-efficiency-booklet-pub.pdfHelen Fairweather, Nick Austinand Meredith Hope, NSW Agriculture. Irrigation Insights No. 5. WATER USE EFFICIENCY..... Volume available for water storage, sprinkler spacing, nozzle size, pressure and wind

Zwart, S.J. and G.M. Bastiaanssen, 2004. Review of measured crop water productivity values for irrigated wheat, rice, cottons and maize. Agri. water Manage. 69: 115–133