

**DESIGN, CONSTRUCTION AND EVALUATION OF AUTOMATIC
GRAVITY-FED WATERING SYSTEM FOR HYDROPONIC
PRODUCTION OF BELL PEPPER (*Capsicum annuum* L.)**

RENZ C. HILARIO

An Undergraduate Thesis Submitted to the Faculty of the Department of Agricultural and
Biosystems Engineering, College of Engineering, Central Luzon State University,
Science City of Muñoz, Nueva Ecija, Philippines
in Partial Fulfillment of the Requirements
for the Degree of

**BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS
ENGINEERING
(Land and Water Resources Engineering)**

JUNE 2019

ACCEPTANCE SHEET

This undergraduate thesis entitled, “**DESIGN, CONSTRUCTION AND EVALUATION OF AUTOMATIC GRAVITY-FED WATERING SYSTEM FOR HYDROPONIC PRODUCTION OF BELL PEPPER (*Capsicum annuum* L.)**,” prepared and submitted by **RENZ C. HILARIO**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (LAND AND WATER RESOURCES ENGINEERING)**, is hereby accepted:


MARVIN M. CINENSE, Ph.D.
Member, Advisory Committee

6/14/19
Date Signed

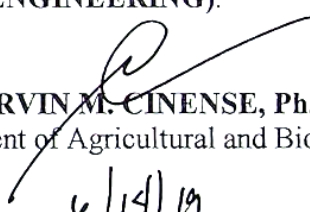

CLAIRE MARIE M. CASTILLO, M.Sc.
Member, Advisory Committee

6/14/19
Date Signed

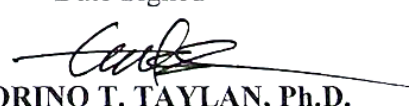

ARMANDO N. ESPINO JR., Ph.D.
Chairperson, Advisory Committee

6/14/19
Date Signed

Accepted as partial fulfillment of the requirements for the degree **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (LAND AND WATER RESOURCES ENGINEERING)**.


MARVIN M. CINENSE, Ph.D.
Chairperson, Department of Agricultural and Biosystems Engineering

6/14/19
Date Signed


VICTORINO T. TAYLAN, Ph.D.
Dean, College of Engineering

6/14/19
Date Signed

BIOGRAPHICAL SKETCH

The author was born on 10th day of February 1998 as the second child of Mr. Delio L. Hilario and Mrs. Lariza C. Hilario and resides at Brgy. Villa Santos, Science City of Muñoz, Nueva Ecija. He was oriented to live simple and humble in every aspect of life and put God as the center of his life.

He completed his primary education at Villa Santos Primary school and continue his elementary education at Rang-ayan Elementary School on 2010. During his schooling he was competed in drawing and other extracurricular activities. After graduation he continued his secondary education at Muñoz National High School (Main). During his secondary level, he become matured in some aspects. He focused on his academics, co-curricular activities, also he become a part of Special Program in the Art (SPA) major in visual arts, where enhance the skills in drawing and painting, SPA is special curriculum in high school and definitely building his character, fortunately, for all the motivations and hard works, he graduated on 2014.

After his graduation, he applied and took an exam for scholarship and fortunately he passed and become a grant of the scholarship of Hon. Nestor L. Alvarez, Ph.D. mayor of Science City of Muñoz, Nueva Ecija.

To reached his dreams, he pursued his tertiary education on the same year at Central Luzon State University and chose Bachelor of Science in Agricultural Engineering as his course. In his first year in college he focused on his academics, also joining intramurals as extracurricular activity as a right winger in football team of College of Engineering. In his 3rd year in college, he decided to join the football and futsal varsity team and become a right defender of the team, two corresponding years where CLSU Green Cobras Football

BIOGRAPHICAL SKETCH

The author was born on 10th day of February 1998 as the second child of Mr. Delio L. Hilario and Mrs. Lariza C. Hilario and resides at Brgy. Villa Santos, Science City of Muñoz, Nueva Ecija. He was oriented to live simple and humble in every aspect of life and put God as the center of his life.

He completed his primary education at Villa Santos Primary school and continue his elementary education at Rang-ayan Elementary School on 2010. During his schooling he was competed in drawing and other extracurricular activities. After graduation he continued his secondary education at Muñoz National High School (Main). During his secondary level, he become matured in some aspects. He focused on his academics, co-curricular activities, also he become a part of Special Program in the Art (SPA) major in visual arts, where enhance the skills in drawing and painting, SPA is special curriculum in high school and definitely building his character, fortunately, for all the motivations and hard works, he graduated on 2014.

After his graduation, he applied and took an exam for scholarship and fortunately he passed and become a grant of the scholarship of Hon. Nestor L. Alvarez, Ph.D. mayor of Science City of Muñoz, Nueva Ecija.

To reached his dreams, he pursued his tertiary education on the same year at Central Luzon State University and chose Bachelor of Science in Agricultural Engineering as his course. In his first year in college he focused on his academics, also joining intramurals as extracurricular activity as a right winger in football team of College of Engineering. In his 3rd year in college, he decided to join the football and futsal varsity team and become a right defender of the team, two corresponding years where CLSU Green Cobras Football

BIOGRAPHICAL SKETCH

The author was born on 10th day of February 1998 as the second child of Mr. Delio L. Hilario and Mrs. Lariza C. Hilario and resides at Brgy. Villa Santos, Science City of Muñoz, Nueva Ecija. He was oriented to live simple and humble in every aspect of life and put God as the center of his life.

He completed his primary education at Villa Santos Primary school and continue his elementary education at Rang-ayan Elementary School on 2010. During his schooling he was competed in drawing and other extracurricular activities. After graduation he continued his secondary education at Muñoz National High School (Main). During his secondary level, he become matured in some aspects. He focused on his academics, co-curricular activities, also he become a part of Special Program in the Art (SPA) major in visual arts, where enhance the skills in drawing and painting, SPA is special curriculum in high school and definitely building his character, fortunately, for all the motivations and hard works, he graduated on 2014.

After his graduation, he applied and took an exam for scholarship and fortunately he passed and become a grant of the scholarship of Hon. Nestor L. Alvarez, Ph.D. mayor of Science City of Muñoz, Nueva Ecija.

To reached his dreams, he pursued his tertiary education on the same year at Central Luzon State University and chose Bachelor of Science in Agricultural Engineering as his course. In his first year in college he focused on his academics, also joining intramurals as extracurricular activity as a right winger in football team of College of Engineering. In his 3rd year in college, he decided to join the football and futsal varsity team and become a right defender of the team, two corresponding years where CLSU Green Cobras Football

team became a champion in SUC III Olympics held in Bulacan and Tarlac and represents Region III in National SUC Olympics that held in the Province of Antique, Western Visayas. As an athlete, his dedication in every game serves as his scholarship.

His college life was well spent and full of challenging lessons that molded him to become an educated person. They were well spent years in building a strong friendship to all the individuals and became his inspiration during ups and downs. In addition, they were well spent because the author was able to develop his capabilities to make his dreams possible.

ACKNOWLEDGMENT

The author would like to express his warmest appreciation, deepest gratitude and sincerest thanks to the following people who contributed and who helped to make this study successful. Without their contributions, the completion of the study will not be accomplished.

Dr. Armando N. Espino Jr., Chairperson of the Advisory Committee and Director of the Land and Water Resources Management Center, for his guidance and supervision, for imparting his knowledge and resources, and for the continuous encouragement towards the fulfillment of this study and for allowing the author to conduct this study in one of the greenhouses at the LWRMC Farm;

Dr. Marvin M. Cinense and Engr. Claire Marie M. Castillo, members of the Advisory Committee for their time, suggestions and comments for the enhancement of this study;

To Dr. Victorino T. Taylan, the dean, and to all faculty and staff of College of Engineering, for their exceptional service and dependability;

Engr. Roldan Quitos and Engr. Christopher Pascual, for providing invaluable guidance and assistance throughout this research;

To Tita Alma, Alliah, Paulo, Sophia and kuya niko who became their second family, he was enthusiastic to finish his thesis. They are diamonds to treasure forever.

To his thesis buddies Dominic, Claire, Joana, Alyssa, Cherish, Karlo, Ron, for their foolish advice, care, untiring effort and support for the success of the author.

To his brothers and sisters, Venus C. Hilario, Genesis C. Ramos, Mikka Cel C. Ramos, Jayson DV. Cabico, Jas DV. Cabico, Xanrine C. Gomez, Jansen D. Cabico, Jashlyn

C. Malabayabas and Joshua C. Malabayabas for sharing stress-relieving moments after a long day at school and special thanks is also given to his Aunties and Uncles who offered their help wholeheartedly;

To his Grandma and Grandpa, Perlita Cabico, Rodolfo Cabico Sr, Teodora Hilario and Romeo Hilario, for their guidance, immense support and pieces of advice.

The reason for the existence of the author, Mr. Delio L. Hilario and Mrs. Lariza C. Hilario, his beloved parents. For the inspiration, encouragement, unconditional love, moral and financial support, for their sacrifice, care, prayers and understanding.

Prodigious praises and thanks to our Almighty God who gives the author a power to believe in himself, to pursue his dreams, provides spiritual guidance and wisdom that gives the author a peace of mind.

And lastly, to those people who were failed to mention, the author extends his never ending appreciation, because you stayed with his in the brightest and darkest days of his life.

To all of them, this humble piece of work is heartily dedicated!

RENZ CABICO HILARIO

TABLE OF CONTENTS

	PAGE
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF APPENDIX TABLES	xiv
LIST OF APPENDIX FIGURES	xv
ABSTRACT	xvi
INTRODUCTION	1
Background of the Study	1
Statement of the Problem	3
Objectives of the Study	4
Significance of the Study	4
Scope and Limitation of the Study	5
Time and Place of the Study	5
REVIEW OF RELATED LITERATURE	6
History of Hydroponics	6
Advantages and Disadvantages of Hydroponics	7
Concept of Hydroponics System	8
Soilless Culture	9
Classification of Hydroponics System	10
Active system	11
Passive system	11
Open system	12
Closed system	12
Greenhouse	12
Types of Culture	14
Basic Components	15
Reservoir	16
Delivery System	16
Growing System	17

Properties of Growing Media	17
Gravity-fed Irrigation	19
Deep Water Culture	19
Advantages	20
Environmental Factors	20
Water Quality Parameters	21
pH	21
Electrical Conductivity	22
Water Temperature	23
Dissolve Oxygen	23
Nutrient Solution	24
Bell Pepper Production	24
Crop Requirement	25
METHODOLOGY	26
Conceptualization of the Study	26
Materials and Equipment	27
Design Consideration	28
Functional Requirement	28
Controller	28
Bucket	28
Metal Frame	28
Wooden Platform	29
Performance Evaluation	29
Preliminary Testing	29
Response of Automated Irrigation System	29
Cultivars	29
Preparation of Seedlings and Transplanting	30
Pest and Disease Management	30
Irrigation and Drainage Management	30
Nutrient Management	30
Data to be Collected	31
Plant height	31

Number of Nodes	31
Number of leaves	31
Water Consumption	31
Other Observation	32
pH	32
EC	32
Nutrient Solution Temperature	32
Dissolve Oxygen	33
Statistical Analysis	33
Experimental Set Up of the Study	33
Experimental Layout	34
Bill of materials	36
RESULTS AND DISCUSSION	37
Design and Construction of the System	37
Assemble of growing pots	37
Construction of wooden platform	38
Construction of the metal frame	38
Performance Evaluation of the System	40
Vertical movement of water affected by bulk density	40
Crop Response	46
Plant Height	46
Number of Leaves	46
Number of Nodes	48
Water Consumption	49
Other observations	50
Temperature	50
Relative Humidity	51
Water Quality Parameters	52
Nutrient Solution Temperature (C°)	52
Level of pH	53

Total Dissolved Solids	54
Bill of Materials	56
SUMMARY, CONCLUSION AND RECOMMENDATION	57
Summary	57
Conclusion	57
Recommendation	58
LITERATURE CITED	59
APPENDICES	63

LIST OF TABLES

TABLE		PAGE
1	Classification of hydroponic system	10
2	Common Nutrient Ranges in Hydroponic nutrient solutions	24
3	Materials and equipment	27
4	Bill of materials	36
5	Bulk density of different media	42
6	Average plant height (cm) at 55 days after transplanting	46
7	Average number of leaves of bell pepper at 55 days after transplanting	47
8	Average number of nodes of bell pepper d at 55 days after transplanting	48

LIST OF FIGURES

FIGURE		PAGE
1	The Different Hydroponic System And Growing Media	15
2	Availability of plant nutrient with respect to pH	22
3	Conceptual Framework	26
4	Design of Automatic Gravity-Fed Hydroponics System	34
5	Experimental Layout	35
6	The growing pots	37
7	Leveling the wooden platform	38
8	Assembling of metal stand for tanks	39
9	Actual set-up of the system	40
10	100% coco coir at different compaction level	41
11	Combination of 50% coco coir and 50% pumice at different compaction level	41
12	Combination of 50% Coco coir and 50% hydroton at different compaction level	42
13	Rate of water movement at uncompact condition	43
14	Rate of water movement at slightly compacted condition	44
15	Rate of water movement at slightly compacted condition	45
16	Weekly average of water consumption of bell pepper	49
17	Daily temperature inside the greenhouse	50
18	Daily change of relative humidity	51
19	Average daily temperature (°C) of the nutrient solution	52
20	pH of nutrient solution at 7:00 am during growing season	53

21	pH of nutrient solution at 2:00 pm during growing season	54
22	Total dissolved solids at 7:00 pm during growing season	55
23	Total dissolved solids at 2:00 pm during growing season	55

LIST OF APPENDIX TABLES

APPENDIX TABLE		PAGE
1	Plant height (cm)	64
2	Analysis of variance on plant height	64
4	Number of leaves	64
5	Analysis of variance on leaves	65
6	Comparison among means on leaves	65
7	Number of nodes	65
8	Analysis of variance on nodes	65
9	Comparison among means on nodes	66

LIST OF APPENDIX FIGURES

APPENDIX FIGURE		PAGE
1	Isometric View	67
2	Side View	68
3	Top View	69
4	Front View	70
5	Cross Sectional View	71
6	100 % coco coir of water at 12 hours of reading	72
7	50% coco coir + 50% pumice level of water at 12 hours of reading	72
8	50% coco coir + 50% hydroton level of water at 12 hours of reading	73
9	Constructed of wooden platform	73
10	Made a hole and put the fittings on the buckets	74
11	Constructed a metal frame for the tanks	74
12	Leveling the wooden platform	75
13	Installation of pipes in the system	75
14	Constructed hydroponics system inside the greenhouse	76
15	Preparation of growing media (pumice and coco coir)	76
16	Preparation of growing media (hydroton and coco coir)	77
17	Transplanting	77
18	Measuring of plant height	78
19	Counting the leaves	78
20	55 days after transplanting	79

ABSTRACT

HILARIO, RENZ C., Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, **June 2019, DESIGN, CONSTRUCTION AND EVALUATION OF AUTOMATIC GRAVITY-FED WATERING SYSTEM FOR HYDROPONIC PRODUCTION OF BELL PEPPER (*Capsicum annuum* L.)**

Adviser: ARMANDO N. ESPINO JR., Ph.D.

This study aimed to determine the most effective agricultural substrate such as 100% coco coir, 50% coco coir + 50% pumice, and 50% coco coir and 50% hydroton used in the production of bell pepper in automatic gravity-fed watering system. The study was conducted from March to May 2019 at LWRMC Farm, Central Luzon State University, Science City of Muñoz, Nueva Ecija. The study was analyzed using the Complete Randomized Design (CRD) and the Least Significant Difference (LSD) was used for the comparison among means.

The study used low cost materials that were readily available in the market and constructed according to plan and their measurements. The performance evaluation of the system that affects due to different levels of compaction. Clarabel F1 was the variety of bell pepper used in the study the maximum height of bell pepper was 32.22cm. Results showed that the bell pepper planted in the 50% coco coir + 50% hydroton had the highest reading recorded among the three treatments in terms of height, number of leaves and number of nodes. Larger pore spaces mean better percolation, and some air holding capacity to keep root zone oxygenated this was the advantages of hydroton that made the 50% coco coir and 50% hydroton have the most successful treatment among the other. The initial investment on automatic gravity-fed calculated Php 14,296.70.

LITERATURE CITED

- ARNARSON, A. (2015). Health Line; Bell Peppers 101. Retrieved on December 2018 from <https://www.healthline.com/nutrition/foods/bell-peppers>
- BAÑEZ, B. P., & MANIPON, F. R. (2000). Crop production under greenhouse and soilless media culture (Los Baños conditions). Paper presented at the workshop on Packaging of Hydroponics R&D Program for High Value Crop Production in the Philippines. PCARRD, Los Baños, Laguna.
- BLOODNICK, E. (2018). Fundamentals of growing media. Retrieved on November 2018 from <https://www.pthorticulture.com/en/training-center/fundamentals-of-growing-media/>
- CARBONEL, F. L. A. (2018). Passive Hydroponic System for Peppermint (*Mentha x piperita*) Production Using Different Growing Media (Undergraduate Thesis Outline). Department of Agricultural and Biosystems Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija.
- CHANDRA, P., & PANWAR J. (1987). Greenhouse technology and its scope in India. In: Proceedings of the national symposium on use of plastics in agriculture, New Delhi, pp 62–66
- DAKTO, S. (2012). San Diego Hydro. Retrieved on January 2019 at <http://sdhydroponics.com/2012/05/08/deep-water-culture-dwc/>
- FULLBLOOM HYDROPONICS. (2018). Hydroponics Systems 101. Retrieved on December 2018 from <https://www.fullbloomhydroponics.net/hydroponic-systems-101/>
- GALINATO, D. (2018). Passive Hydroponic system of Basil (*Ocimum Basilicum* L.) production using different Growing media. Cental Luzon State University, Science City of Munoz, Nueva Ecija
- GOMEZ-LOPEZ, M. D., FERNANDEZ-TRUJILLO J. P., & BAILLE. (2006). Cucumber fruit quality and harvest affected by soilless system, crop and age pre-harvest climatic conditions during consecutive seasons. *Science Horticulture* 110:68-78.
- HANAN, J. J., HONEY, W. D., & GOLDSBERRY, K. L. (1978). Greenhose management. Springer, New York
- HAZE, N. (2009). Best Coco Coir Nutrients for Cannabis. Retrieved on December 2018 from <http://www.growweedeasy.com/best-coco-nutrients-canabis>

- HOMESTEADING. (2019). Gravity Fed Water Systems: A Simple Overview. Retrieved on February 2019 from <https://homesteading.com/gravity-fed-water-systems-overview/>
- HUBACEK, K., & VAZQUEZ, J. (2002), *The economics of land use change*. Interim Report, IR-02-015. The Economics of Land Use Change Klaus Hubacek, IIASA
- JOHNSON, JR. H. (1980). "Hydroponics: A guide to soilless culture. University of California. Division of Agriculture and Natural Resources, pp. 2947.
- KAISER, C., & ERNST, M. (2018). Bell Peppers. Center for Crop Diversification Crop Profile CCD-CP-87. UK Extension Specialist, International & Sustainable Agriculture. University of Kentucky College of Agriculture, Food and Environment.
- KLAASEN, P. (2018). Electrical conductivity, why it matters. Retrieved on November 2018 from <http://www.cannagardening.com/electrical-conductivity>
- LEAFFIN. (2017). Best Hydroponics Media –Buyer’s Guide. Retrieved on December 2018 from <http://www.leaffin.com/growing-media-aquaponics-hydroponics/>
- LOWERY, B., & WOLKOWSKI, R. (2008). Soil compaction: Causes, Concerns, and Cures (A3367). University of Wisconsin-Extension. Retrieved on May 2019 from <http://sheboygan.extension.wisc.edu>
- LYKAS, C. (2001). Nutrient solution management recirculating soilless culture of Rose in mild winter climates. *Acta horticulture*, Vol. 559, No. 1, (Oct 2001), pp. 543-548, ISSN 0567-7572
- MAX. (2017). The History of Hydroponics. Retrieved on October 2018 from <https://www.greenandvibrant.com/history-of-hydroponics>
- MAX. (2017). Hydroponic Growing Media 101 - The Ultimate Guide Retrieved on January 2019 from <https://www.greenandvibrant.com/growing-media>
- MORGAN, L. (2017). The Convenience of Hydroponic Nutrient Application Systems. Retrieved on November 2018 from <https://www.maximumyield.com/the-convenience-of-hydroponic-nutrient-application-systems/2/3077>
- MORGAN, L. (2016). The micro revolution: Growing Hydroponic Microgreen. Maximum Yield. Nutrient Reservoir. Retrieved on November 2018 from <https://www.maximumyield.com/definition/3156/nutrient-reservoir>

- NAVILLE, E. H. (1913). *The Temple of Deir el-Bahari (Parts I–III)*, Vol. 16. London: Memoirs of the Egypt Exploration Fund. pp. 12–17.
- NOSOILSOLUTION. (2018). How to grow sweet hydroponic sweet pepper. Retrieved on December 2018 from <http://www.nosoilsolutions.com/how-to-grow-hydroponic-bell-peppers/>
- OLIVIA'S SOLUTION. (2013). Advantages & Disadvantages of Hydroponics! Retrieved on February 2019 from <http://www.oliviassolutions.com/blog/advantages-disadvantages-of-hydroponics/>
- OS, E. V., BLOK, C., VOOGT, W., & WAKED, L. (2016). Water quality and salinity aspects in hydroponic cultivation
- PANTUHAN, G. (2016). Hydroponics: Concepts and Methods, retrieved on October 2018 from <http://pguims-random-science.blogspot.com/2012/05/hydroponics-concepts-and-methods.html>
- PIMENTEL, D., BERGER, B., FILIBERTO, D., NEWTON, M., WOLFE, B., KARABINAKIS, E., CLARK, S., POON, E., ABBETT, E., NANDAOPAL, S. (2004). *Water Resources, Agriculture, and the Environment*. Ithaca (NY): New York State College of Agriculture and Life Sciences, Cornell University. Report 04-1.
- REDDY, P. P. (2015). *Greenhouse Technology. Sustainable Crop Protection under Protected Cultivation*, DOI 10.1007/978-981-287-952-3_2
- RHOADES, H. (2019). Gardening Know How. Retrieved on May 2019 from <http://www.gardeningknowhow.com/edible/vegetables/pepper/pepper-yellow-leaves.htm>
- SACE, C. F., & AGULTO, I. C. (2013). *Water Management for hydroponic honeydew Melon Production* (ISBN 978-3-639-51691-3), Scholars press Publishing, AV Akadmikerlag gnbH &Co. KG, Heinrich- Bocking- Str.6-8,66121, Saarbrucken, Germany.
- SAVVAS, D., GIANQUINTO, G., TUZEL, Y., & GRUDA, N. (2013). Good Agricultural Practices for greenhouse vegetable crops, Principles for Mediterranean climate areas. Retrieved on October 2018 from <https://www.researchgate.net/publication/255700929>
- SILVA, L. H., & YAMASHITA, M. T. (2008). The dimension of the pore space in sponges. IOP Publishing Ltd. Retrieved on November 2018 from <http://iopscience.iop.org/article/10.1088/0143-0807/30/1/013>

- STOCKER. (2004). What is Hydroponics? Stocker horticultural & hydroponic supplies (2004) ltd. Retrieved on February 2019 from <http://www.hydroponics.co.nz/stockers.pdf>
- VARADARAJAN, P. D. (1963). Climate and soil conditions of *Rauwolfia Serpentina* in India. Volume 17, Issue 2, pp 133–138. Retrieved on November 2018 from <https://link.springer.com/article/10.1007/BF02985363>
- VERTICAL FARM. (2014). Advantages and Disadvantages Hydroponics and Soilless Culture. Aeroponic and hydroponic systems, urban farms and vertical. Technology and innovation for the future. Retrieved on February 2019 from http://verticalfarm.altervista.org/advantages-disadvantages-hydroponics-soilless-culture/?doing_wp_cron=1509110639.2960400581359863281250
- ZABELTITZ, C. V. (1997). Integrated Greenhouse Systems for Mild Climates: Climate Conditions, Design, Construction, Maintenance, Climate Control.