

**FLAT DIE MODIFICATION AND PERFORMANCE EVALUATION OF A  
RETROFITTED FORTIFIED ORGANIC FERTILIZER  
PELLETING MACHINE**

**ELIZALDE I. ESCAT II**

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 Munoz,  
Nueva Ecija, Philippines in Partial Fulfillment  
of the Requirements for degree of


**BACHELOR OF SCIENCE IN AGRICULTURAL  
AND BIOSYSTEMS ENGINEERING  
(Agricultural Mechanization and Renewable Energy)**

**JUNE 2019**

ACCEPTANCE SHEET


This undergraduate thesis entitled “**FLAT DIE MODIFICATION AND PERFORMANCE EVALUATION OF A RETROFITTED FORTIFIED ORGANIC FERTILIZER PELLETTING MACHINE,**” prepared and submitted by **ELIZALDE I. ESCAT II**, in partial fulfillment of the requirement for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AGRICULTURAL MECHANIZATION AND RENEWABLE ENERGY)**, is hereby approved:


  
**ROMEO B. GAVINO, Ph. D.**  
Member, Advisory Committee

  
**MARLON N. GALAD, M.Sc.**  
Member, Advisory Committee

\_\_\_\_\_  
Date Signed

\_\_\_\_\_  
Date Signed

  
**HELEN F. GAVINO, Ph. D.**  
Chairperson, Advisory Committee

  
**ARMAN M. PARAYAO, Ph. D.**  
Co-Chairperson, Advisory Committee

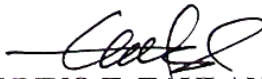
06-10-2019  
Date Signed

06-13-19  
Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AGRICULTURAL MECHANIZATION AND RENEWABLE ENERGY)**:

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

6/13/19  
Date Signed

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

6/13/19  
Date Signed

## **BIOGRAPHICAL SKETCH**

Elizalde Irang Esact II, the fourth child of Mr. Elizalde C. Escat and Mrs. Imelda I. Escat, was born on the 25<sup>th</sup> day of October year 1997 and currentky living with his family at 061 Purok 1, Brgy. Malayantoc, Sto. Domingo, Nueva Ecija.

In the year 2009, He finished his elementary education at Malayantoc Elementary School (MES) and graduated as 1<sup>st</sup> honorable mention. For his secondary education, he went to Santo Domingo National Trade School (SDNTS). And four years after, year 2014, he finished his secondary education in which he majored in automotive servicing accredited by Technical Education and Skills Development Authority (TESDA). He came from a simple family and with the support of his parents and brothers, he was able to pursue my tertiary education. With his father as an official in their barangay, he was able to get discount on his tuition fees.

Elizade I. Escat II originally planned on taking up Mechanical Engineering course in Nueva Ecija University of Science and Technology (NEUST) because of its relevance to his high school major, but concluded that the demand in Agriculture is increasing, and so he decided to take Bachelor of Science in Agricultural and Biosystems Engineering major in Agricultural Mechanization and Renewable Energy at Central Luzon State University (CLSU).

## ACKNOWLEDGMENT

This study would not have been made possible if were not for the people who shared their knowledge, ideas, support, and encouragement and have helped the researcher in times of need. Therefore, the author wishes to express his sincere gratitude to the people who have helped him in this study and to those who have made his life in Central Luzon State University fun and worthwhile.

The author would like to express his deepest gratitude to the following:

Dr. Helen F. Gavino, Chairperson of the Advisory Committee, for her advices, knowledge, guidance, valuable inputs, and encouragement made for the study;

Dr. Arman M. Parayao, Co-chairperson of the Advisory Committee, for his guidance, advices, knowledge, and assistance in the making of the study;

Dr. Romeo B. Gavino and Engr. Marlon N. Galad, members of the Advisory Committee, for their valuable suggestions, constructive criticism, and positive encouragement;

His parents, Elizalde C. Escat and Imelda I. Escat, for their endless love, encouragement, support financially or emotionally, and for believing in him;

His siblings, Zamhee, Ervin Irish, Nazarene, and Mariel Lerizza, for their support afinancially and emorionally and for giving him motivations;

His girlfriend, Michelle Hanh C. Le, for always being by his side in times of ups or down, for encouraging him to do his best all the time, for everything that she have given especially for helping in conducting the study and finishing the papers of this study;

All of his BSABE friends, for their support and help in the progress of this study and also for making his life in CLSU so much more fun;

And above all, to the Almighty GOD, for His grace and mercy, guidance and protection have helped the author overcome every struggle that he encountered, for the LORD have given him blessings, knowledge, wisdom, understanding, and strength whenever and wherever needed to make this study possible.

## TABLE OF CONTENTS

	PAGE
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF APPENDIX TABLES	xi
LIST OF APPENDIX FIGURES	xii
ABSTRACT	xiv
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	7
Pellets	7
The Pelleting Process	8
Components of a Die-turned Pellet Mill	10
Pellet Die Specifications	11
Die Selection	12
Clearance Between The Roller And Die	13
Performance Evaluation of Machinery	13
Organic Fertilizer	14
Vermicompost	14
Combined Organic and Inorganic Fertilizer	15
Moisture Content of the Compost for Pelleting	16
Soil Bacteria and Fungi	17
Temperature and Microbial Growth	18
Suitable Timing of application of pelletized compost	18
Microbe Inoculant	19

Microbe inoculant Application	21
Cost Analysis	21
Fixed Cost	22
Depreciation	22
Interest on Investment	22
Taxes, Housing, and Insurance	23
Variable Cost	23
Repairs and Maintenance	23
Labor Cost	24
METHODOLOGY	25
Conceptualization of the Study	25
Design Considerations on Modification of Flat Die	26
Modification of the Flat Die	27
Principle of Operation	27
Preparation of Materials	29
Substrate	29
Binder and Binder Application	29
Microbe Inoculant Solution and Application	30
Instrument and Materials for Testing	30
Performance Evaluation of the Machine	31
Machine Test and Maintenance	31
Preliminary Testing	31
Final Testing	32
Data gathered	32
Pelleting Capacity	33
Pelleting Efficiency	34
Pelleting Density	34
Evaluation Microbes Present in the Pellet	35
Statistical Analysis	35
Experimental Layout	36
Cost Analysis	37
Fixed Cost	37
Depreciation	37
Interest on Investment	37
Taxes, Insurance, and Housing	37

Variable Cost	38
Annual Cost	38
Cost of Pelleting per kilogram	38
Break-even Point	38
Net Income	39
Payback Period	39
<b>RESULTS AND DISCUSSION</b>	<b>40</b>
Description of the Modified Flat Die	40
Performance Evaluation of the Machine	41
Pelleting Capacity	41
Pellet Efficiency	42
Pellet Density	44
Volume Reduction	45
Microbial Count	46
Bacteria	46
Yeasts and Molds	48
Cost Analysis	49
<b>SUMMARY, CONCLUSION AND RECOMMENDATION</b>	<b>52</b>
Summary	52
Conclusions	54
Recommendations	55
<b>LITERATURE CITED</b>	<b>56</b>
<b>APPENDICES</b>	<b>59</b>
Appendix A – Appendix Tables	60
Appendix B – Pelleting Pressure Computation	65
Appendix C – Appendix Figures	71

## LIST OF TABLES

TABLE		PAGE
1	Lists of components of a die-turned pellet mill	10
2	Nutrient value of vermicompost	15
3	Instruments and materials to be used during the performance evaluation of the machine	31
4	Factor used in the study	36
5	Specification of the modified flat die	40
6	Pelleting capacity of the machine as affected by type of die and application of inoculant	42
7	Pellet efficiency of the pellets produced by the machine as affected by type of die and application of inoculant	44
8	Pellet density of the pellets produced by the machine affected by type of die and application of inoculant	45
9	Volume reduction caused by pelleting	46
10	Microbial count of bacteria in the samples of the pellets produced by the machine affected by type of die and application of inoculant	48
11	Costs and assumptions used in the study	49
12	Cost Analysis.	50

## LIST OF FIGURES

FIGURE		PAGE
1	Pellets	6
2	Force analysis of pelleting in a flat die	7
3	Flat Type Pellet Press	8
4	Ring Type Pellet Press	8
5	Components of a Die-turned Pellet Mill	9
6	Cross Section of a flat die	11
7	Roller and die clearance	13
8	Microbial count of pelletized compost	19
9	Example of commercially available microbial inoculant	20
10	Conceptual Framework of the Study	26
11	Flow of operation on pellet production	29
12	Experimental layout of the study	36
13	Modified flat die	41
14	Mean pelleting capacity of the machine	41
15	Mean pellet efficiency of the pellets produced	43
16	Mean pellet density of the pellets produced	44
17	Microbial count of bacteria in the samples	47
18	Sample of petrifilm with too few to count yeast and mold	49
19	Cost curve of fortified pellet production	51

## LIST OF APENDIX TABLES

APPENDIX TABLE		PAGE
1	Raw data for the peletting capacity of the machine	61
1a	Computed pelleting capacity of the machine	61
1b	Analysis of variance on the pelleting capacity of the machine	62
2	Raw data on sieving for the pellet efficiency computation	62
2a	Computed pellet efficiency	63
2b	Analysis of variance on the pellet efficiency	63
3	Raw data for the pellet density computation	63
3a	Computed pellet density	64
3b	Analysis of variance on the pellet density	64
4	Number of bacterial colonies	64
4a	Microbial count of bacteria in the samples	65
4b	Analysis of variance on the microbial count of bacteria in the samples	65
5	Particulars in computation of pelleting pressure	65

## LIST OF APENDIX FIGURES

APPENDIX FIGURE		PAGE
1	Preparation of substrate material	67
1a	Preparation of substrate material	67
2	Repackaging of substrate	68
3	Repackaged substrate	68
4	Samples and cans used for moisture content determination	69
5	Weighing of samples for moisture content determination	69
6	Samples subjected to microwave drying	70
7	Sieving of samples prior to repackaging	70
8	Weighing of repacked samples	71
9	Installation of motor for the mixing chamber	71
10	Disassembling of pelleting unit prior to cleaning	72
11	Preparation of binder-inoculant solution	72
12	Binder unit installation	73
13	Machine ready prior to pretesting	73
14	Preliminary testing of the machine	74
15	Final testing of the machine	74
16	Sample pellets on the first die	75
17	Sample pellets from modified die	75
18	Modified flat die	76
19	Die from previous study	76
20	Sieving of pellets for pellet efficiency	77
21	Inoculant solution preparation	77

22	Inoculant solution to be applied after pelleting	78
23	Application of inoculant after pelleting	78
24	Weighing of samples in a known volume	79
25	Pellet to be stored for 7 days	79
26	Microbe inoculant used	80
28	Instruments used	80
29	Samples for evaluation of microbes	81
30	Preparation of diluent of samples	81
31	Diluents to be subjected to sterilization by autoclave	82
32	Autoclave machine	82
33	Sterilized diluents on test tubes	83
34	Weighing of samples to be diluted	84
35	Diluted samples at 1:10 ratio	84
36	Pipetting of diluted samples for different ratios	85
37	Pipetting of diluted sample to petrifilms	85
38	Incubation of petrifilms	86
39	Petrifilm at 1:10,000,000	86
40	Petrifilm at 1:100,000 ratio of sample solution	87
41	Petrifilm at 1:1,000 ratio of sample solution	87
42	Manual counting of colony forming	88
43	Drawing Layout of Modified Flat Die	89
44	Specifications of Modified Flat Die	90

## ABSTRACT

**ESCAT, ELIZALDE II I.**, Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines, **June 2019**, **FLAT DIE MODIFICATION AND PERFORMANCE EVALUATION OF A RETROFFITED FORTIFIED ORGANIC FERTILIZER PELLETING MACHINE.**

Adviser: HELEN F. GAVINO, Ph. D.

Co-Adviser: ARMAN M. PARAYAO, Ph. D.

This study was conducted to produce quality fortified organic fertilizer pellets by modifying the die of the machine and altering the application of the microbe inoculant for the benefit of Filipino farmers who seek to improve the quality of organic farming. The specific objective of this study was to: modify the die of the organic fertilizer pelleting machine; compare the performance of the original and modified machine and pellet quality in terms of pelleting capacity, pellet density, and pellet efficiency; evaluate the change of microbial count by introduction of inoculant before and after pelleting; and perform cost analysis..

Based on the results of the study, the modified die has a higher pelleting capacity than the die from the previous study, with mean values of 80.03 and 65.27kg/hr, respectively. On the other hand, the efficiency of pellets produced was higher in the previous die than the modified die with mean values of 95.50 and 85.49%, respectively. For the pellet density, the modified die produced the higher density pellets at mean of 758.36kg/m<sup>3</sup> and the volume reduced was 25% of its original volume.

The results on the evaluation of microbes present in the pellets showed it is highly effective to apply inoculant after pelleting. The bacterial colony count of the substrate before pelleting was averaged at 14.23 million cfu per gram of samples. The highest

## LITERATURE CITED

- Adepetu, J. A. (1997). Soil and Nigeria food security. Inaugural lecture series 119. OAU, Ile-Ife pp19
- Application rates for vermicompost - The Compost Club. Vermicompost From Waste DFID-NRSP-R8192. [compostclub.org/wp-content/uploads/2010/06/2273.pdf](http://compostclub.org/wp-content/uploads/2010/06/2273.pdf)
- Behnke K. C. (2001). Factors Influencing Pellet Quality. Department of Grain Science and Industry. Kansas State University Manhattan, Kansas, USA 66506-2201. <https://pdfs.semanticscholar.org/43d9/1d59f6cda3cf69aa6f12e61ac1c33b832ec7.pdf>
- Behnke, K.C. (2001). Kansas State University. The art of pelleting. <http://www.feedmachinery.com>
- Bunthan, N. & Lalita, S. (2009). Suitable Timing of Application Of Pelletized Compost And Farmers' Acceptance In Cambodia. Royal University of Agriculture, Cambodia. Association of Environmental and Rural Development, Thailand. [issaas.org/journal/v15/01/journal-issaas-v15n1-bunthan.pdf](http://issaas.org/journal/v15/01/journal-issaas-v15n1-bunthan.pdf)
- Daniyan, Ilesanmi & M. Omokhuale, A & A. Aderoba, A & Ikumapayi, Omolayo & Adaramola, Bernard. (2017). Development and performance evaluation of organic fertilizer machinery. Cogent Engineering. 4. 10.1080/23311916.2017.1364044. [www.researchgate.net](http://www.researchgate.net)
- Edwards, W. (2015). Estimating Farm Machinery Costs. <https://www.extension.iastate.edu/agdm/crops/html/a3-29.html>
- Eneji, A. E. Agboola, A.A. and Ibi, B.E. (1997). Effect of farmyard manure and NPK fertilizer on growth and yield of intercropped maize and sweet potato in southwestern Nigeria. *Rivista di Agricoltura subtropicale tropicale* 91: 63-78.
- Food and Fertilizer Technology Center. Microbial and Organic Fertilizers in Asia. <http://www.ffc.agnet.org/library.php?func=view&id=20110803182212>
- Food and Agriculture Organization of the United Nations (FAO-UN, 2001). AGP - Soil biological management with beneficial microorganisms. <http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/soil-biodiversity/case-studies/soil-biological-management-with-beneficial-microorganisms/en/>
- GEMCO – Energy. What Are The Parts Of A Flat Die Pellet Mill? <http://www.gemcoperletmills.com/pellet-mill-parts.html>

- Greg Reid & Percy Wong (2005). Soil Bacteria and Fungi. New South Wales Department of Primary Industries. [www.soilquality.org.au](http://www.soilquality.org.au)
- Gordon, D.P. (2009). New Zealand Inventory of Biodiversity. Vol. 1: Kingdom Animalia – Radiata, Lophotrochozoa, Deuterostomia. Canterbury University Press, Christchurch.
- Hara, M. (2001). Fertilizer Pellets Made from Composted Livestock Manure. Agriculture Research Division. Mie Prefectural Science and Technology Promotion Center. Kawasakita 530, Uresinocho, Itisigun, Mie, 515-2316, Japan. [www.ffc.agnet.org](http://www.ffc.agnet.org)
- Hunt, D.R. (2001). Farm Power and Machinery Management – 10<sup>th</sup> Edition. USA: Iowa State University Press.
- Imatong, H. (2015). Intensifying Fortified Compost Pellets: A New Farming Management Option in Kalinga. Vol. 2, Issue 5, pp: (1-6). [www.noveltyjournals.com](http://www.noveltyjournals.com).
- Imatong, H. & Gavino, R. & Aguinaldo, T. (2012). Performance Evaluation of a Retrofitted Fortified Organic Fertilizer Pelleting Machine. [www.researchgate.net](http://www.researchgate.net)
- Japkowicz, Nathalie & Shah, Mohak. (2015). Performance Evaluation in Machine Learning. [www.researchgate.net](http://www.researchgate.net)
- Kaltschmitt, M., Hartmann, H. & Hofbauer, H. (2009). Biomass Briquettes – Production: Pan Grinder Presses for Pelletizing. [https://energypedia.info/wiki/Biomass\\_Briquettes\\_-\\_Production](https://energypedia.info/wiki/Biomass_Briquettes_-_Production)
- Landers, S. & Eslan, A. Why and How to Conduct a Cost Analysis. JSI Research & Training Institute, Inc. [cba.jsi.com](http://cba.jsi.com)
- Lisle, B. (2013). "The History of the Wood Pellet Industry on the East Coast." In Wood-Based Energy in the Northern Forests, edited by M. Jacobson and D. Ciolkosz. New York: Springer Science and Business Media.
- Lumen – Microbiology. Temperature and Microbial Growth. <https://courses.lumenlearning.com/microbiology/chapter/temperature-and-microbial-growth/>
- Usman M., V.U. Madu, & G. Alkali (2015). The Combined Use of Organic and Inorganic Fertilizers for Improving Maize Crop Productivity in Nigeria. International Journal of Scientific and Research Publications, Volume 5, Issue 10, October 2015. [www.ijsrp.org/research-paper-1015/ijsrp-p4698.pdf](http://www.ijsrp.org/research-paper-1015/ijsrp-p4698.pdf)

- Nagy, C.N. (2000). Greenhouse Gas Emission Coefficients for inputs used in agriculture. Report to the Prairie Adaptation Research Cooperative (PARC), Center for Studies in Agriculture, Law and the Environment. <http://www.sciencedirect.com>.
- Ojeniyi, S. O. (2002). Soil management, national resources and environment. Oke-Ado: Adeniran press. Pp 24.
- Pellet Dies. [https://www.feedmachinery.com/glossary/equipment/pellet\\_dies/](https://www.feedmachinery.com/glossary/equipment/pellet_dies/)
- Ojeniyi, S.O. & Adeniyi, M. O. (1999). Effect of poultry manure and NPK fertilizer on soil fertility and maize nutrient contents and yield at Akra southwestern Nigeria. Proceedings of 25th Annual Conference of Soil Science Society of Nigeria (SSSN). Benin. Pp 185-191.
- Olajire-Ajayi BL, et. al, (2015). Effects of fertilizers on soil's microbial growth and populations: a review. American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-4, Issue-7, pp-52-61 [www.ajer.org](http://www.ajer.org)
- Suyal, Deep Chandra & Soni, Ravindra & Sai, Santosh & Goel, Reeta. (2016). Microbial Inoculants as Biofertilizer. 10.1007/978-81-322-2647-5\_18. [www.researchgate.net](http://www.researchgate.net)
- Singh, R. (2012). Organic Fertilizers: Types, Production and Environmental Impact. [www.researchgate.net](http://www.researchgate.net)
- The Pelleting Process. California Pellet Mill Co. <https://www.cpm.net/downloads/Animal%20Feed%20Pelleting.pdf>
- TICO – Pellet Making. How to maintain pellet mill die and roller? <http://www.pellet-making.com/blog/maintain-pellet-mill-die-and-roller.html>
- Zuberer, D.A. Soil Microbiology FAQ's. <http://organiclifestyles.tamu.edu/soil/microbe/index.html#top>