SPRAYING APPLICATION EFFICIENCY AND SPREADER UNIFORMITY OF REMOTELY PILOTED AIRCRAFT SYSTEM

CHRISTINE ANNE A. BILLONES
GABRIELLE T. SANDOVAL

An Undergraduate Thesis Manuscript Submitted to 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 the Degree of

BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING
(AB Machinery and Power Engineering)

December 2023

ACCEPTANCE SHEET

This undergraduate thesis manuscript entitled **"SPRAYING APPLICATION EFFICIENCY AND SPREADER UNIFORMITY OF REMOTELY PILOTED AIRCRAFT SYSTEM"** prepared and submitted by **CHRISTINE ANNE A. BILLONES** and **GABRIELLE T. SANDOVAL**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB MACHINERY AND POWER ENGINEERING)**, is hereby accepted:

ROLDAN T. QUITOS, M. Sc.
Member. Advisory Committee

JANUARY 9, 2024
Date Signed

JONATHAN V. FABULA, Ph.D.
Member. Advisory Committee

JANUARY 10, 2024
Date Signed

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

1/9/2024
Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB MACHINERY AND POWER ENGINEERING):**

ELMAR M. VILLOTA, Ph.D.
Head, Department of Agricultural and Biosystems Engineering

JANUARY 10, 2024
Date Signed

THEODY B. SAYCO, Ph.D.
Dean, College of Engineering

JANUARY 15, 2024
Date Signed

BIOGRAPHICAL SKETCH

The author, Christine Anne A. Billones, was born on December 23, 2000 in Quezon City. She is the second child among four children of Mr. Roland A. Billones and Jocelyn A. Billones. She has three siblings named Joanne A. Billones, Aileen A. Billones, and Roselyn A. Billones. She completed her primary education in 2013 at Manuel L. Quezon Elementary School. In 2017, she completed junior high school in Commonwealth High School and finished her senior year of high school at Lagro High School in 2019 under STEM strand. As a passionate student, she joined multiple organizations during her secondary school years which made her choose this field. In 2019, she enrolled in college with a degree in Bachelor of Science in Agricultural and Biosystems Engineering at Central Luzon State University. She is an active member of the CLSU – Society of Agricultural and Biosystems Engineering Students (CLSU SAGES-PSABE), a preparatory professional group which honed her skills and developed her attitude.

The author, Gabrielle T. Sandoval was born on August 28, 1999 in Dinalupihan, Bataan. She is the eldest child of Ms. Charisma Tantiangco. She has two siblings named Maria Miguelle T. Sandoval and Victoria Ysraelle T. Sandoval. She completed her primary education at Hermosa Elementary School, school year 2011-2012. She had her junior high school years of secondary education at Saint Peter of Verona Academy, and finished her senior high school years at Saint John Academy, Inc., school year 2017-2018. She pursued her tertiary education at Central Luzon State University at Science City of Muñoz, Nueva Ecija, where she took up Bachelor of Science in Agricultural and Biosystems Engineering

with area of specialization in AB Machinery and Power Engineering. During her stay at Central Luzon State University, she joined Society of Agricultural and Biosystems Engineering Students – Philippine Society of Agricultural and Biosystems Engineering (SAGES – PSABE), a college-based organization which helped her to develop her skills and build her personality.

ACKNOWLEDGEMENT

This study would not have been possible without the ideas, knowledge, support, and encouragement of the people who extended their hands toward the completion of this work. Thus, the author wants to express her deepest gratitude to recognize the following individuals:

To Dr. Marvin M. Cinense, chairperson of the advisory committee, for his guidance, immense support, and advice during the conduct of the study;

To Dr. Jonathan V. Fabula and Engr. Roldan T. Quitos, M. Sc., members of the advisory committee, for their constructive criticism and suggestions during the study;

To all the faculty and staff of the Department of Agricultural and Biosystems Engineering for their exceptional service and passion to educate;

To the Philippine-Sino Center for Agricultural Technology (PhilSCAT) and SAGES-PSABE CLSU. To Sir Danilo, Sir Aldo, Sir Francis, Sir Ed, and Sir Jerome for their assistance and for providing the necessary resources for the study;

To the family of the researchers for their moral and financial support and the motivation they have given to finish this thesis manuscript;

To Almighty God, above all, for giving strength, knowledge, and his provision and guidance to overcome the challenges the researchers faced.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

LIST OF APPENDIX TABLES

LIST OF APPENDIX FIGURES

LIST OF FORMULAS

ABSTRACT

BILLONES, CHRISTINE ANNE A. and SANDOVAL, GABRIELLE T., Department of Agricultural and Biosystems Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines, **December 2023**, **SPRAYING APPLICATION EFFICIENCY AND SPREADER UNIFORMITY OF REMOTELY PILOTED AIRCRAFT SYSTEM.**

Adviser: MARVIN M. CINENSE, Ph.D

Drone technology has advanced significantly over the last two decades in terms of flight stability, sensor capability, battery life, and price. Because of these improvements, drones are now more widely available and useful for a variety of industries, including agriculture. However, there aren't many reputable studies on RPAS because they are still relatively new and developing technology. Thus, this study was conducted to evaluate the performance of the RPAS' spreading system and application efficiency of the RPAS' spraying system. The RPAS spreading system was evaluated using distribution uniformity (DU) given its parameters. Performance parameters such as output rate, uniformity of distribution, effective swath width, and application rate were analyzed. The data were analyzed using t-test. Each test had three replicates each at a single pass application of the RPAS to assess the uniformity of the spreading system. A flight height of 3 m at different flight speeds of 3 m/s and 5 m/s were assessed.

The DU value for determining the uniformity of distribution of the RPAS varied from 79.15% at 50% overlap with an effective swath width of 12 meters and 3 m/s forward speed; and 88.50% at 40% overlap with an effective swath width of 11 meters and 5 m/s forward speed for fertilizer aerial spreader application. For the rice seed aerial spreader application, the data obtained were 69.35% and 82.70% at 50% overlap with an effective

swath width of 12 and 11 meters, at 3 m/s and 5 m/s, respectively. The output rate of the RPAS varied from 2425 kg/hr for 3 m/s and 2368 kg/min for 5 m/s for fertilizer; and 507 kg/hr for 3 m/s and 535 kg/hr for 5 m/s for rice seed. The application rate of the RPAS for fertilizer varied from 186.20 kg/ha for 3 m/s and 126.36 kg/ha for 5 m/s. According to Department of Agriculture, 150 kg/ha is the minimum recommended application rate for 14-14-14 fertilizer. With this, 3 m/s showed an efficient result. The rice seed application rate varied from 39.17 kg/ha for 3 m/s and 27.06 kg/ha for 5 m/s for rice seed. According to PhilRice, 40 kg rice seeds is required to be planted in a hectare. With this, 3 m/s showed an efficient result.

The application efficiency of the RPAS spraying system was evaluated by dividing the water stored in the testing area over the water applied. Each test had three replicates each with the RPAS operating steadily above the testing area. Different flight heights were considered in the evaluation of the spraying application efficiency. The application efficiency of the RPAS varied from 50.63% for the 3 meter flight height, and 41% for the 4 meter flight height.

LITERATURE CITED

Ahmad, F., Khaliq, A., Qiu, B., Sultan, M., & Ma, J. (2021). *Advancements of Spraying Technology in Agriculture*. IntechOpen. doi: 10.5772/intechopen.98500

Allagui, Asma & Bahrouni, Hassouna & Youssef, M'Sadak. (2018). *Deposition of Pesticide to the Soil and Plant Retention During Crop Spraying: The Art State*. Journal of Agricultural Science. 10. 104. 10.5539/jas.v10n12p104.

Allen, M. J., & Lin, V. (2007). *Guidance and control of an autonomous soaring UAV* (No. H-2714).

Chen, H., Lan, Y., Fritz, B. K., Hoffmann, W. C., & Liu, S. (2021). *Review of agricultural spraying technologies for plant protection using unmanned aerial vehicle (UAV)*. International Journal of Agricultural and Biological Engineering, 14(1), 38–49. https://doi.org/10.25165/ijabe.v14i1.5714

Das, N., Maske, N.M., Khawas, V., Choudhary, S., & Dethe, E.R. (2015). *Agricultural Fertilizers and Pesticides Sprayers - A Review*. International Journal for Innovative Research in Science and Technology, *1*, 44-47.

Das, S. (2021). *Agriculture Drone: From Sci-Fi to Reality. Al Ardh Al Khadra Agricultural*. Soil-Conditioner Factory L.L.C. Retrieved from https://www.aaaksc.com/agriculture-drone/

Dascalu, J. (2022, March 8). *Aerodynamics of multirotor drones*. GlobalSpec. https://insights.globalspec.com/article/18303/aerodynamics-of-multirotor-drones

Davies, E. (2021). *Pesticide Drift: Causes and Adverse Health Effects*. Retrieved from https://www.drugwatcher.org/effects-of-pesticide-drift/

Dekoulis, G. (Ed.). (2020). *Autonomous Vehicles*. IntechOpen. doi: 10.5772/intechopen.73376

Department of Agriculture. (2002). *GUIDELINES ON THE SCALING UP THE USE OF MICROBIAL-BASED FERTILIZERS AS INTERVENTION TO REDUCE COST OF PRODUCTION IN RICE FARMING*. Retrieved from https://www.da.gov.ph/wp-content/uploads/2022/02/ao04_s2022.pdf

DJI (n.d.). *Agras T30*. Retrieved from https://www.dji.com/t30

Evaluate the Weather. (n.d.). *Pesticide Environmental Stewardship*. https://pesticidestewardship.org/pesticide-drift/evaluate-the-

weather/#:~:text=Wind%20speeds%20above%208%20mph,and%20may%20change%20direction%20rapidly.

Fishel, F.M., & Ferrell, J.A. (2010). *Managing Pesticide Drift*. EDIS. Retrieved from https://edis.ifas.ufl.edu/publication/PI232

Gardisser, D.R. & Kuhlman, D.K. (2001). *Agricultural Aircraft Calibration and Setup for Spraying*. Cooperative Extension Service, University of Arkansas, U.S. Department of Agriculture, and County Governments Cooperating.

Haman, D., & Yagar, T. (2022, July 26). *FIELD EVALUATION OF CONTAINER NURSERY IRRIGATION SYSTEMS: MEASURING UNIFORMITY OF WATER APPLICATION OF SPRINKLER SYSTEMS*. Ask IFAS - Powered by EDIS. https://edis.ifas.ufl.edu/publication/AE194

International Fertilizer Development Centre (IFDC). *Fertilizer Deep Placement* (FDP); IFDC: Muscle Shoals, AL, USA, 2013; Retrieved from https://ifdc.org/fertilizer-deep-placement/

International Rice Research Institute. (n.d.). *Direct seeding - IRRI Rice Knowledge Bank*. Retrieved from http://www.knowledgebank.irri.org/step-by-step-production/growth/planting/direct-seeding

Jamala, G.Y., Ari, B.M., Tsunda, B.M. and Waindu, C. (2013), "*Assessment of agro-chemicals utilization by small-scale farmers in Guyuk, Adamawa State, Nigeria*," Journal of Agriculture and Veterinary Science, Vol. 6 No.2, pp. 51-59

Kruger, G., Robert, K., Ogg, C., & Vieira, B. (2019, September). *Spray Drift of Pesticides*. extensionpublications.unl.edu. Retrieved from https://extensionpublications.unl.edu/assets/pdf/g1773.pdf?fbclid=IwAR0FF0WJYGY2xpms4yYKp9bkSKhBHBBRZGgRGsIRg1ko2QFyPOd99Xj93lg

Laksham K. B. (2019). *Unmanned aerial vehicle (drones) in public health: A SWOT analysis*. Journal of family medicine and primary care, *8*(2), 342–346. https://doi.org/10.4103/jfmpc.jfmpc_413_18

Lu, J. L. (2010). *Analysis of Trends of the Types of Pesticide Used, Residues and Related Factors among Farmers in the Largest Vegetable Producing Area in the Philippines*. Journal of rural medicine: JRM, 5(2), 184–189. https://doi.org/10.2185/jrm.5.184

Martos, V., Ahmad, A., Cartujo, P., Ordoñez, J. (2021). *Ensuring Agricultural Sustainability through Remote Sensing in the Era of Agriculture 5.0*. Appl. Sci. 2021, 11, 5911. https://doi.org/10.3390/app11135911

Meola, A. (2021). *Precision agriculture in 2021: The future of farming is using drones and sensors for efficient mapping and spraying*. Retrieved from https://www.businessinsider.com/agricultural-drones-precision-mapping-spraying

Murison, M. (2020). *Fixed-Wing vs Multirotor: Which Drone Should You Choose for Aerial Surveying? DJI Enterprise*. Retrieved from https://enterprise-insights.dji.com/blog/fixed-wing-vs-multirotor-drone-surveying

Naji, I. (2019). "The Drones' Impact on Precision Agriculture." *ETD Collection for University of Texas, El Paso*. AAI27668778. https://scholarworks.utep.edu/dissertations/AAI27668778

Nordin, M. N., Jusoh, M. S. M., Bakar, B. H. A., Ahmad, M. T., Mail, M. F., Vun, C. T., Chuang, T. C., Basri, M. S. H., & Zolkafli, A. K. (2021). *Study on Water Distribution of Spraying Drone by different Speed and Altitude*. Advances in Agricultural and Food Research Journal. https://doi.org/10.36877/aafrj.a0000215

Pajares, G. (2015). Overview and current status of remote sensing applications based on unmanned aerial Vehicles (UAVs). *Photogrammetric Engineering and Remote Sensing*, *81*(4), 281–330. https://doi.org/10.14358/pers.81.4.281

Pathak P., Damle M., Pal P.R., Yadav V. (2019). *Humanitarian impact of drones in healthcare and disaster management*. Int. J. Recent Technol. Eng. 2019;7(5):201–205.

Rees, C. (2015, March 31). *Arcturus JUMPTM15 Fixed Wing VTOL UAV | Unmanned Systems Technology*. Unmanned Systems Technology. https://www.unmannedsystemstechnology.com/video/arcturus-jump15-fixed-wing-vtol-uav/

S386.2; ASABE Standards. Calibration and Distribution Pattern Testing of Agricultural Aerial Application Equipment. ASABE: St. Joseph, MI, USA, 2018.

Simula, A. (2021). *Establishing drone technology to agriculture as a service provider*. JAMK University of Applied Sciences. Retrieved from https://www.theseus.fi/bitstream/handle/10024/504391/Opinn%C3%A4ytety%C3%B6_Antti_Simula.pdf?sequence=2

Singh, I. (2021). *What's the difference between drones, UAS, UAV, and RPAS?* Retrieved from https://dronedj.com/2021/12/07/drone-uav-uas-difference-explained/

Syam, H., Jamaluddin, & Rahman, K. (n.d.). *Design and test of unmanned aerial vehicle (UAV) spraying capacity in quadcopter based plant spraying system*. Universitas Negeri Makassar. ISBN: 978-623-7496-62-5

Tomas, M. (2022, January 27). *40kg of high-quality rice seeds enough for 1-ha field*. Philippine Rice Research Institute. https://www.philrice.gov.ph/40kg-of-high-quality-rice-seeds-enough-for-1-ha-field/

Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., & Phung, D. T. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment. *International journal of environmental research and public health*, *18*(3), 1112. https://doi.org/10.3390/ijerph18031112

UAV Systems. *What Is A Fixed Wing Drone? | Advantages And Uses Of Fixed Wing Drones*. UAV Systems International. Retrieved from https://uavsystemsinternational.com/blogs/drone-guides/what-is-a-fixed-wing-drone-advantages-and-uses-of-fixed-wing-drones

University of Massachusetts Amherst. (2016, October 26). *Sprayers and spray application techniques*. Center for Agriculture, Food, and the Environment. https://ag.umass.edu/greenhouse-floriculture/fact-sheets/sprayers-spray-application-techniques

Yang, S., Yang, X., & Mo, J. (2017). The application of unmanned aircraft systems to plant protection in China. *Precision Agriculture*, *19*(2), 278–292. https://doi.org/10.1007/s11119-017-9516-7

Yinka-Banjo, C., & Ajayi, O. (2020). Sky-Farmers: Applications of Unmanned Aerial Vehicles (UAV) in agriculture. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.89488

Zhang Y L, Lian Q, Zhang W. (2017). Design and test of a six-rotor unmanned aerial vehicle (UAV) electrostatic spraying system for crop protection. Int J Agric & Biol Eng, 2017; 10(6): 68–76.