FERTILIZER-IN-BUBBLE RELEASING SYSTEM FOR AN UNMANNED AIRCRAFT (DRONE) FOR AGRICULTURE

Benya Kasantikul*

Mechanical Engineering Department, Faculty of Engineering, Kasetsart University,
Kamphaeng Saen Campus.

ABSTRACT

Thailand is an agricultural country so farmers are in danger in contacting chemicals, insecticides, and fertilizers. This work was on a fertilizer –in-bubble releasing system that allowed farmers to fertilize plants safely without having to contact with chemicals and could save the amount of fertilizer solution. The ultrasonic atomization technique was introduced in this bubble releasing system. The result of the test to find the dispersion of bubbles released when attached to the aircraft revealed that there was very little dispersion when the bubbles were coming down from the aircraft which was about 1.5-3 meters higher than the top of plants. Also, it was found that the rate of use of the fertilizer solution was just 400 cc/hour. The result showed that the bubble releasing system could save the fertilizer volume more 90% than that of the old fertilizer spraying system. The dispersion areas of the bubble released varied according to the height range.

KEYWORDS: Fertilizer application by bubble spraying, unmanned aircraft (drone)

* Corresponding: Benya Kasantikul
E-mail: benya.k@ku.th

INTRODUCTION

Thailand is rich and fertile in agriculture and therefore has many agricultural products exported to foreign countries or it is well-known as an agricultural country so farmers have to produce agricultural products continuously and more to domestically sell and export to foreign countries. They therefore use fertilizers or plant hormones or other plant growth accelerators to increase the potential for agricultural production. Most Thai farmers prefer to use spraying methods for fertilizers or plant hormones; thus, they have to carry sprayers on the back and walk around to spray in their farms. This may cause the risk of their skins hit by chemicals even if they protect themselves by wearing gloves or wearing clothes completely. Accordingly at present, various methods of fertilizer spraying which are safer have been invented such as those using a car, using a balloon, and using drones to help spray. Huang et al. (2009) have discussed the design of agricultural spray systems for small UAV's. Ru et al. (2011) designed electrostatic rotary atomizers for low volume application. Wang et al. (2013) has investigated the use of multiple UAV's flying in coordinated fleets for spray application. Giles & Billing (2014) studied about spray deposition and work rate data to analyse the technical and economic feasibility of UAV deployment in agricultural spray applications and deployed to find the performance of UAV for crop spraying (Giles & Billing, 2015).

The use of UAV or drones is safer and can spray more at the point that we need than the use of car or using a balloon because it can choose the spraying position more specifically. In addition, adaptation of spray techniques can also help increase overall crop productivity and also helps reduce the effects harmful to the environment (Opanukul et al., 2017) as well. At present, the use of spraying drones has become increasingly popular but there is still a problem of fertilizer loss in vain because some fertilizers do not get all the plant leaves due to falling to the ground instead. The old spraying method of fertilizer makes it impossible to hit every part of the leaf blade because the method causes high momentum. Thus, the fertilizer will be just on the leaves and then splashed out, causing no fertilizer under the leaves. Resulting from the ultrasonic atomization which has been used in aviation agriculture systems (Sindayihebura et al., 1997), the new concept to have a vapour generator for the fertilizer solution before and then its vapour obtained is packed into the bubbles before spraying into plants. The main principle is to change the normal spray to be a bubble releasing spray. Within the bubble, there will be fertilizer vapour. This is to increase the area in which the leaves will receive fertilizer solution thoroughly, both the back and front of the leaves and also save the amount of fertilizer solution. This new system of bubble spraying will cause surface tension of the bubbles so they stick to all parts of the leaves for a period of time and not being distributed into the soil. Moreover, the quantity of fertilizer is economically used because the ultrasonic atomizer transforms the solution of fertilizer with water into vapour.

The objective of this research is to create a fertilizer-in-bubble releasing system which helps save the fertilizer solution.

MATERIALS AND METHODS

As shown in Fig. 1 and 2 are materials in this study:

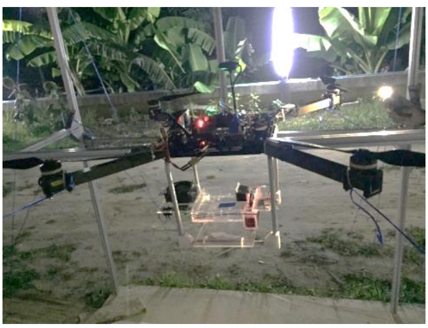


Fig. 1 a drone together with the fertilizer-in-bubble releasing system installed

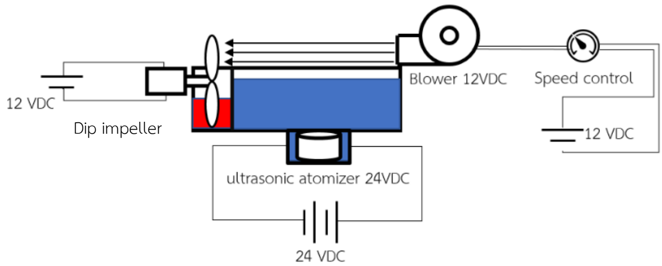


Fig. 2 fertilizer-in-bubble releasing system (FBRS)

This study method was conducted after steps are as follows:

1) literature review,

2) study and data collection,

3) designing and

4) developing and testing.

4.1) The FBRS tests:

- Test of bubbling efficiency
- Test of putting fertilizer vapor in the bubbles

4.2) Test of bubble mixing ratio

4.3) Tests after the FBRS installation on the drone

- Test of bubble dispersion
- Test of bubble dispersion on the plant

RESULTS

1) Test of Bubbling Efficiency

Fig. 3 test result of bubble efficiency within 30 seconds

During the designing and development of the FBRS, the speed control of the blower was set up at 50%. The FBRS could create approximately 960 bubbles/second and the amount of fertilizer vapour was at 400 cc/hr. as shown in fig.3.

2) Test results of putting fertilizer vapour into the bubbles

Fig. 4 Test result of putting fertilizer vapour into the bubbles

This experiment was conducted in a full system with an internal vapour generator set, where the result of the test was that there was a certain amount of vapour in the bubbles as shown in Fig. 4.

3) Test results of bubble mixing ratio

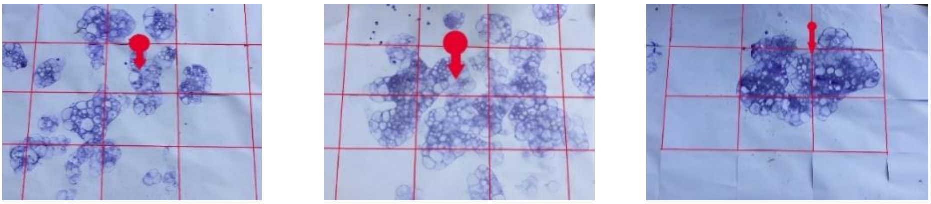
Table 1 Test results of bubble mixing ratio and duration of bubble formation

Test	Mixing Ratio	Average Duration(seconds)
1	Bubble agents 60 % Glycerine 10 % Water 30 %	4.97
2	Bubble agents 60 % Glycerine 5 % Water 35 %	4.63
3	Bubble agents 40 % Glycerine 10 % Water 50 %	3.29
4	Bubble agents 40 % Glycerine 5 % Water 55 %	2.95

According to Table 1, the test results show that the volume of Glycerine affects the bubbling duration; thus, the addition of Glycerine at different concentrations significantly results in increased or less bubbling duration.

4) Test results of bubble dispersion of the FBRS

As shown in Fig. 5, at different levels of height, the bubble dispersions vary as follows: At the 1.5-meter height, the bubble dispersion is 0.29 m^2; at the 2.2-meter height, the bubble dispersion is 0.53 m^2; at the 3.0-meter height, the bubble dispersion is 0.80 m^2. These relationships can graphically be seen in Fig. 6 where the x axis is the height above the plant top target and the y axis is the dispersion areas of the bubbles.



(a) (b) (c)

Fig. 5 Test results of bubble dispersion at different levels:
(a) 1.5 m. (b) 2.2 m. and (c) 3.0 m.

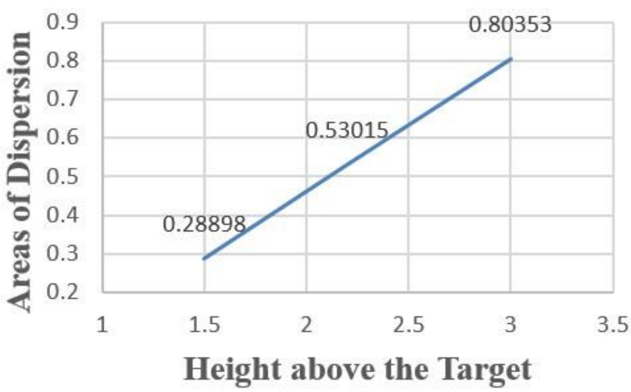


Fig. 6 Relationships between the height above the target (meters) and the areas of dispersion (square meter)

5) Test results of bubble dispersion on the plant

(a)

(b)

Fig. 7 (a) Result of the bubbles on the plant leaves, (b) The fertilizer solution coated on the leaves and branches after the bubble breakage

Fig. 8 Water droplets flowing down by gravity

Fig. 7 (a) shows that the bubbles stick to the leaves very well. Because the bubbles are larger than the leaves, resulting in that after a bubble has broken out, the leaves are simultaneously coated with the fertilizer solution as shown in Fig. 7 (b). Meanwhile, some bubbles that fall on the branches will break into water droplets, flow through the branches and drop to the ground due to the gravity of the world.

DISCUSSIONS

According to the study results, the FBRS can practically be used with plants tested to have a total weight of 1.916 kilograms. Bubbles were counted by sensor at about 960 balls per minute resulting from the proper control of motor speed of the drone. When the FBRS is installed on an unmanned aircraft/drone, the wind force from the propeller lifting force will make the bubbles drop down to the target. The test results suggest that at the heights ranging from 1.5 to 3 meters, the area of the bubble dispersion is likely to increase after the increasing height. Compared to the study by Opanukul et al. (2017) where at the heights between 1.5 – 2.5 meters, it takes time at averagely 3 - 5 minutes/rai which is shorter than the FBRS time which takes 10 minutes/rai; however, the FBRS has more bubbles covering 50% of the plant area than that of Opanukul et al. (2017) which has just 33 bubbles covering only 10-20%. And these 33 bubbles covering per square centimeters is enough effective area. (Opanukul et al., 2017).

Due to the wind force resulting from the propeller’s lifting force together with the increasing heights, the bubbles are then easily blown away and the area of dispersion increases steadily as linear relation to the increasing height. However, this error will result very little if the plant is fairly large. According to the virtual test with the plants, the bubbles stick to the leaves for a period of time before gradually breaking out and flowing along the leaves of the plant. The time that the bubbles will gradually dilute and eventually break down depends on the mixing ratio of bubble formation in which Glycerine is the main component. Thus, Glycerine is the most important part that will make the bubble last longer and helps to make the last-long bubbles even last longer (Sindayihebura et al., 1997). If 40% of the bubble forming substance is used, the bubble will stay for 2.9 seconds before breaking out. However, if it is mixed with Glycerine, the bubble will last for at least 0.4 seconds longer. As for the fertilizer vapor in the bubble, unfortunately, its volume is still less. This problem may be due to the movement of the vapor in the designed pipe is not good enough to generate more enough vapor. The vapor evaporation volume is 400 ml/hour. However, in the 4-rotor unmanned aircraft/drone, the FBRS will normally release the fertilizer solution at the rate of 4 liters/hour (Opanukul et al., 2017).

It can be definitely concluded that the FBRS can save the fertilizer solution 10 times better than the old normal spraying system. When analysed in economics aspect, the device of Opanukul et al. (2017) costs 100,000 baht, the FBRS costs 51,250 baht, saving more than 48.75 percent. Calculating payback period based on 1 litter of fertilizer solution costs 150 Baht, the payback period is 379.63 hours of use.

More over the FBRS is also able to help farmers save on fertilizer, help them not to touch chemicals resulting in increased work safety, and reduce the floating chemicals in the air and pollution to the environment.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support of this study by Faculty of Engineering, Kamphean Saen Campus and thank to Mr. Puwadol K. and Mr. Sorawich T., for their help on machine fabrication and performing the test.

REFERENCES

Giles, D. K., & Billing, R. (2014). Unmanned aerial platforms for spraying: deployment and performance. *Aspects of Appl. Bio., 12*, 63-69.

Giles, D. K., & Billing, R. (2015). Deployment and Performance of a UAV for Crop Spraying. *Chem. Eng. Trans*., *44*, 307-312.

Huang, Y., Hoffmann, W. C., Lan, Y., Wu, W., & Fritz, B. K. (2009). Development of a spray system for an unmanned aerial vehicle platform. *Appl. Eng. in Ag., 25*, 803-809.

Opanukul, W., Saikumfu A., Punwattato P., Tientad I., Thondang B. & Sukprasert W. (2017). *Drone research for organic agriculture*. In: The 18th TSAE National Conference. 7-9 September 2017. Thailand.

Ru, Y., Zhou, H., Fan, Q., & Wu, X. (2011). *Design and investigation of ultra-low volume centrifugal spraying system on aerial plant protection*. Paper No. 11-10663, American Society of Agricultural and Biological Engineers. Presented at Louisville, KY USA.

Sindayihebura, D., Dobre M., & Bolle L. (1997). *Experimental study of thin liquid film ultrasonic atomization.* pp, 1249-1256. In: Proceedings of ExHFT-4, Brussels, Belgium.

Wang, Z., Lan, Y., Hoffmann, W. C., Wang, Y., & Zheng, Y. (2013). *Low altitude and multiple helicopter formation in precision agriculture*. Paper No. 13-1618681, American Society of Agricultural and Biological Engineers. Presented at Kansas City, MO, USA.