Design And Test Of Unmanned Aerial Vehicle (UAV) Spraying Capacity In Quadcopter Based Plant Spraying System

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Abstract. Spraying is one of the important stages in plant cultivation, especially in spraying fertilizers. One form of technology development carried out is to create a quadcopter-based unmanned aerial vehicle (UAV) that can spray automatically. This study aims to examine the performance of an unmanned aerial vehicle (UAV) in an agricultural spraying system. In this study, a quadcopter-based UAV was designed to maximize the efficiency of spraying agricultural land with a capacity of 10L. The UAV has 4 nozzle holes arranged horizontally. Measurement parameters to see the performance of the UAV are water discharge capacity, working width, working speed, spraying capacity. Based on the test results, the average water discharge released is 1.29 liters / minute, spraying working width is 2.36 m, working speed is 2.7 m / s, spraying work capacity is 0.20 l / m2.

Keywords: UAV, spraying, plants, capacity.

INTRODUCTION

Technology is a form of product in the development of science and technology that can facilitate a particular job or activity. The influence of technological developments in the 21st century has had an increasingly growing influence or invasion, this influence has entered various sectors of activity and at various levels or human circles. The influence of technology that is increasingly developing must be followed by user knowledge and understanding regarding how to make wise use of existing technology, so this development needs to be balanced with the ability of human resources (HR) who must also develop, this step is something that must be done as a demand. from the increasing competition in the world of work in the current era, namely the industrial revolution 4.0. The key in facing the Industrial Revolution 4.0 is in addition to preparing for technological progress, on the other hand it is necessary to develop human resources from the humanities side so that the negative impacts of technological development can be suppressed (Banu and Umi, 2018).

The 21st century, which is the era of the industrial revolution 4.0, has various kinds of challenges and risks that must be faced by every human being as a form of adaptation to the development of automation technology. According to Tjandrawinata (2016), one of the unique characteristics of industry 4.0 is the application of artificial intelligence. The application of artificial intelligence in the form of robot technology is currently very developed in every sector, including

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government, health, education, industry and agriculture. Irianto (2017) simplifies the challenges of industry 4.0, namely; (1) industrial readiness; (2) trusted workforce; (3) ease of socio-cultural arrangements; and (4) diversification and job creation. Every human being must be able to solve various kinds of challenges so that new problems do not occur. Problem solving in the present era must be carried out wisely and in a structured manner so that every human being can see the opportunities and strengths that can be exploited from any existing challenges.

The agricultural sector in Indonesia has always received attention and support from the government in its development process because it is one of the largest economic sources in Indonesia. Development is carried out so that the production process can be made more effective and efficient. The efforts of the government in developing the agricultural sector in the industrial era 4.0 are carried out by making innovations that can be used by the community, especially farmers, to improve their production processes and results. Examples of forms of innovation are the creation of a planting calendar application (Katam), smart farming, autonomous tractor, smart greenhouse, smart irrigation and many other agricultural applications that can be easily accessed online. In all processes carried out in an effort to develop agricultural production, there is one stage that has an important role in carrying out the process of cultivating plants as an effort to provide nutrients, namely fertilization. The provision of various fertilizers can increase the need for nutrients and improve the physical, chemical and biological properties of the soil and fertilization will increase the life of organisms in the soil (Haryadi, et al. 2015).

The fertilization process in the era of the industrial revolution 4.0 is still predominantly carried out in the traditional way by everyone. The traditional technique is done by fertilizing using a carrying sprayer. The sprayer functions to change or break down the spray solution carried out by the nozzle, into very fine parts or granules (Djojosumorto, 2004). Fertilization using a sprayer can only spray one row of plants in one operation path, so that its working capacity is low (Hermawan, 2012). In addition, the time used is relatively longer and there is a risk of exposure to chemicals if fertilization is not carried out in accordance with established procedures, so this method is still classified as less effective and efficient. This is in accordance with the opinion of Djafar, et al. (2017) which states that the type of sprayer that is widely used by farmers in the field is the hand sprayer type (pump type), but the results are less effective and less efficient.

Based on the description of problems related to fertilization using a sprayer in the era of the 4.0 industrial revolution which always maximizes the use of automation technology to make work more effective and efficient, it is necessary to improve the performance of the sprayer and its spraying system. Improvement efforts that can be made by designing and testing the performance of an Unmanned Aerial Vehicle (UAV) based fertilizer or known as a quadcopter-based unmanned aircraft can carry out the process of spraying land automatically.

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RESEARCH METHODS

A. Research Design

The form of this research is engineering / design research. In this study, an analysis of the electrical and mechanical requirements and performance testing of fertilizer unmanned aerial vehicle (UAV) was carried out. The following is a design drawing of the design in this study:

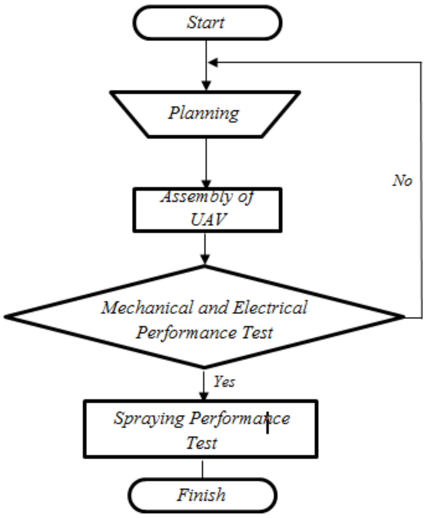

Figure 1. Design tool making

B. Research Location

The research will be carried out in the Agricultural Technology Education Study Program, Faculty of Engineering, Makassar State University for 4 (four) months.

C. Data Analysis Technique

The data analysis technique used in this research is quantitative data analysis techniques with descriptive statistics, the data obtained is tabulated into tables and interpreted through graphs which will then become a reference in making descriptions of the work test of the tool.

D. Design and Construction Procedure

The design procedure in this study was carried out with the following procedures:

1. Literature and observation studies, namely conducting a theoretical study of the design of a quadcopter-based Unmanned Aerial Vehicle (UAV) combined with a spraying system for agricultural activities, namely fertilizing and spraying pests using liquid media
2. The preparation stage, namely preparing the tools and materials to be used: UAV components, sprayer components, controller components, performance test instruments and other equipment and ensure they are in standard conditions.
3. Technical design, manufacturing design, assembly and settings through the Graphic User Interface (GUI).

4. to test the work performance of unmanned aircraft that are experiencing design development. In each test, what needs to be done is measurement and recording including the performance and stability of unmanned aircraft (UAV) and the effectiveness of fertilizer spraying.

E. UAV testing

UAV Water Discharge

Water discharge is measured using the following equation:

$$Q = \frac{v}{t}$$

Ket.
Q = water discharge (liter / minute)
v = Flow Volume (liter)
t = working time (minutes)

Work speed

The working speed of the tool is measured using the following equation:

$$V = \frac{s}{t}$$

V = tool forward speed (meter / second)
s = distance (m)
t = working time (seconds)

UAV working capacity

The working capacity of the tool is measured using the following equation:

$$KP = \frac{Q}{v.L}$$

Ket.
KP = Spraying Capacity (m^3 / m^2)
Q = water discharge (liter / minute)
v = forward speed (m / h)
L = working width (m)

RESULT AND DISCUSSION

A. Fertilizer Sprayer UAV Design

The drone design is carried out based on problem analysis by farmers in traditional fertilization. The technology design is made so that it is easy for farmers to operate and can do the job effectively and efficiently, especially in spraying fertilizers.

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Figure 2. UAV Fertilizer Sprayer

UAV design uses the concept of a quadcopter drone, which is a drone with 4 propulsion motors. the motor used has a torque of about 14 kg per motor after using a 30 inch propeller and a power source of 84000 Mah, 50.4 v. Each drone axis has a length of 150 cm with an X-shaped axis. Maximum tank capacity for spraying is 10 liters. The nozzles that are owned are 4 pieces arranged horizontally. UAV are capable of conducting flights using the way point method so that spraying can be carried out automatically at a speed and altitude that can be adjusted in the mission planner application. The flight control used is the pixhawk with radiolink GPS SE 100, GPS is very important in the development of the UAV so that every flight mode that is carried out automatically can be done precisely to lock the home flight point, so that when a failsafe or low battery occurs, the UAV will return to the starting point of the flight.

B. UAV Testing Results

Water Discharge Capacity

The UAV water discharge capacity test is carried out in a stationary condition, which is stored at a height of 100 cm because this measure is the average value of the UAV height when used in land fertilization which has been set in the mission planner application, so that the UAV flight control will continue to maintain the altitude when spraying . Fertilizer UAV discharge data can be seen in table 1.

Table 1. Fertilizer UAV discharge data

Deuteronomy	Fertilizer UAV Discharge (Liter / Minute)	Time (Minute)
1	1.25	8
2	1.28	7.8
3	1.28	7.8
4	1.32	7.6
5	1.32	7.6
Average	**1.29**	

Checking the UAV discharge was carried out 5 times, from 5 repetitions the average UAV discharge was 1.29 liters / minute. in replications 1 - 5 there is an increase in water flow due to the difference in the RPM of the spray pump motor rotation, the RPM difference is due to the pump motor setting which is still done manually by turning the potentiometer on the transmitter, the difference in rotation

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angle will result in a difference in RPM on the pump motor which also affects the discharge of water released but the difference in water flow in each experiment has very little difference, namely in the range of 0.03 - 0.07 liters / minute because the water pressure and size of the PE hose are the same at each nozzle. This is in accordance with the opinion of Yuwana (2014) that the same pressure and passing through a cross section (pipe) of the same diameter causes the flow rate to flow is the same so that the volume of liquid that comes out of the nozzle has almost the same value.

Working Width

Testing the working width of the fertilizer UAV was carried out in a stationary condition, which was stored at a height of 100 cm. The measurement of the working width is done by manually measuring the width of the spray from the UAV. The number of nozzles used in the UAV is 4 in a horizontal position with a distance of 50 cm between the nozzles. The liquid that comes out is made to fog up because the misting method is the most effective way to distribute pesticides to the surface of the plant (Dharmawan and Soekarno, 2020). The width of the fertilizer UAV spray can be seen in table 2.

Table 2. Width of Fertilizer UAV spray

Deutoromy	*Height (m)*	*Working Wide (m)*
1	1	2.4
2	1	2.2
3	1	2.3
4	1	2.4
5	1	2.5
Average		**2.36**

Spraying work width trials were carried out 5 times, the average working width of the UAV for 5 replications was 2.36 m. The highest working width was in the fifth test, namely 2.5 m, while the lowest was in the second test, which was 2.2 m. the difference in the width of the spray was the highest for each replication, namely 30 cm. This difference is caused by the different RPM of the motor pump every time it is repeated. The difference in the RPM of the pump motor is due to the rotation of the knob to turn on the pump which is still done manually at the transmitter. The rotation that is done manually results in a slight difference in knob angle which has an impact on the value of the pump rotation / pump motor RPM.

Working Speed

The results of the work speed test are carried out by first making the settings on the flight control (FC) in the Qground control application. FC settings include flight route, UAV altitude and forward speed. The following are the results of the forward / working speed test of the sprayer UAV.

$$V = \frac{s}{t}$$
$$V = \frac{25\,m}{9\,s}$$
$$V = 2{,}7\,m/s$$

The forward speed set on the FC is 3 m/s in the 25 field test, but based on the test results, the actual forward speed obtained is 2.7 m/s.

Spraying Capacity

The spraying capacity is measured by dividing the water flow rate by the forward speed and the working width. The results of the spraying capacity test can be seen as follows:

$$Kp = \frac{1{,}29\,liter/minute}{2{,}7 m/s\ x\ 2{,}36\,m}$$
$$Kp = \frac{1{,}29\,l/m}{6{,}37\,m^2/s}$$
$$Kp = 0{,}20\,l/m^2$$

Based on the calculation results, the spraying capacity of the UAV is 0.20 l / m^2. The spraying capacity in the field basically depends on the speed of the operator (UAV), the number of nozzels used, the width of the spray and the pressure used (Daywin, et al. 1992).

CONCLUSION

The UAV design is made in the form of a quadcopter drone that uses 4 main motors, the maximum torque capacity of the UAV is 56 kg with a liquid holding capacity of 10L. The maximum flight time for UAVs with a maximum load is 9 minutes for a battery usage of 50.4v 8400 Mah. The UAV has 4 spray nozzles arranged horizontally. UAVs are capable of conducting flights using the way point method so that spraying can be carried out automatically at a speed and altitude that can be adjusted in the mission planner application. Based on the results of functional trials, UAV sprayers have very good performance compared to conventional sprayers. The UAV has an average water discharge capacity of 1.29 liters/minute, a working width of 2.36 meters, a working speed of 2.7 m/s, and a spraying capacity based on water flow data, the spraying width and the working speed are 0.20 l / m^2.

REFERENCE

[1] Banu Prasetyo, Umi. T. 2018. *Revolusi Industri 4.0 dan Tantangan Perubahan Sosial*. Prosiding SEMATEKSOS 3 "Strategi Pembangunan Nasional Menghadapi Revolusi Industri 4.0" , 22-27.

[2] Daywin, F. J., Sitompul, R. G., dan Imam, H. 1992. *Mesin-mesin Budidaya Pertanian*. Bogor: JICA-DGHE/IPBProject.

ISBN: 978-623-7496-62-5

[3] Djafar, R., Djamalu, Y., Sunarti, A., E.. 2017. *Desain Dan Pengujian Sprayer Gulma Tipe Dorong*. Jurnal Teknologi Pertanian Gorontalo , Volume 2 Nomor 2, Oktober 2017.

[4] Djojosumartono, P. 2004. *Teknik Aplikasi Pestisida Pertanian*. Kanisius, Yogyakarta

[5] Haryadi D., Yetti, H., Yoseva, S. 2015**.** *Pengaruh Pemberian Beberapa Jenis Pupuk Terhadap Pertumbuhan Dan Produksi Tanaman Kailan (Brassica Alboglabra L.)* . Jom Faperta Vol.2 No. 2 Oktober 2015

[6] Irianto, D. 2017. *Industry 4.0; The Challenges of Tomorrow***.** Disampaikan pada Seminar Nasional Teknik Industri, Batu-Malang.

[7] Rahman, M. N., dan Yamin, M. 2014. *Modifikasi Nosel pada Sistem Penyemprotan untuk Pengendalian Gulma Menggunakan Sprayer Gendong Elektrik*. Jurnal Keteknikan Pertanian, 2

[8] Tjandrawina, R.R. 2016. *Industri 4.0: Revolusi industri abad ini dan pengaruhnya pada bidang kesehatan dan bioteknologi*. Jurnal Medicinus, Vol 29, Nomor 1, Edisi April.

[9] Yuwana, N. A. 2014. *Desain dan Kontruksi Grid Patter nator untuk Pengujian Kinerja Penyemprotan Sprayer.* Skripsi . Bogor : Institut Pertanian Bogor.