

¹K.V.Vrama Raju¹,

D.r.Ch.

Vijayakumar²,K.Ravi Kmar³,N. Sandeep⁴

Drone Operation Agriculture Sprayer In The Paddy Field



Abstract- The agricultural sector is very promising; yet, it now has various challenges, one of which is the shortage of labor for farming. Extreme weather conditions, insufficient supplies, improper fertilizer application, infections, illnesses, allergies, and other health complications resulting from chemical treatments (fungicides, pesticides, insecticides, etc.) or bites from insects or animals are other challenges. Drones have shown to be an effective method for rapid and non-invasive assessment of air quality, soil physical properties, and crop development, hence addressing several challenges in agriculture via the use of sustainable ICTs. Consequently, farmers are using advanced drone technology to address these challenges swiftly and efficiently. Drones may collect data on several subjects, such as agricultural yields, animal health, soil quality, nutrient evaluations, meteorological patterns, and precipitation totals. Nonetheless, there is a lack of research addressing the benefits of drone use among rice farmers in Malaysia. This study seeks to determine the parameters influencing Malaysian paddy farmers' use of drones. This study gathers data from interviews with 10 paddy farmers who own agricultural drones to achieve this purpose. Farmers have been chosen from Tanjung Karang to Sabak Bernam, where paddy agriculture is thriving, particularly in Selangor, Malaysia. Government agencies may subsequently use the findings from this study and local authorities to delineate recommendations for paddy farmers on the benefits of using drones in rice cultivation. Additionally, the government might explore methods to assist farmers financially in acquiring additional drones.

Keywords: Agriculture Drone, Spraying, Paddy Fields, DJI Drone, Paddy Farmers.

INTRODUCTION

Agriculture serves as the primary food supply globally and has considerable challenges stemming from increasing demand for food products, concerns over food safety and security, as well as requirements for environmental preservation, water conservation, and sustainability. The global population is projected to reach 9.7 billion individuals by 2050. Consequently, this tendency is anticipated to persist. It is expected that both food demand and water consumption will increase substantially in the near future, with agriculture being the most prominent instance of worldwide water use.

Approximately 50% of the global population consumes rice as a staple food, with 90% of the world's rice production occurring in Asia, where rice farming is prevalent. Nevertheless, just 7% of the nation's overall rice output is exported. Consequently, rice and paddy are vital for several developing countries' initiatives to guarantee food security, maintain sociocultural traditions, and implement strategic interventions. With the exception of Australia, the United States, and many South American countries, the majority of the world's paddy fields are cultivated on a modest scale. Consequently, rice cultivation supports the livelihoods of millions of smallholder farming families and landless agricultural workers throughout Asia. Small-scale farming differs from Malaysia's rice production, which occurs on moderately small plots of less than two hectares and includes around 194,000 farmers. A limited tract of land results in diminished productivity and elevated production expenses. This nation is somewhat hindered in attaining complete self-sufficiency owing to insufficient economies of scale. Malaysia has eight primary paddy granary regions, regarded as the nation's rice bowl and a cornerstone of food security. The National Agricultural Policy (NAP) of 1984–1991 allocated certain wetland paddy regions upon the establishment of primary granary zones. This may be seen as a tactical initiative to bolster the development of the paddy and rice sectors while ensuring the nation's food security. Although additional minor paddy fields are dispersed around the nation, paddy farmers have established themselves in these primary granary regions [6]. Only a few aid programs are available to the granary regions, which have alleviated poverty and enhanced the lives of paddy farmers. In 2017, the average yield per hectare in these areas was 4.47 mt/ha, surpassing the national

¹Assistant Professor, Department Of Agricultural Engineering, International School Of Technology And Sciences For Women, A.P, India.

²Professor, Department Of Agricultural Engineering, International School Of Technology And Sciences For Women, A.P, India.

^{3,4}Associate Professor, Department Of Agricultural Engineering, International School Of Technology And Sciences For Women, A.P, India.

average yield of 4.03 mt/ha. Four out of eight granaries (MADA, KETARA, IADA Pulau Pinang, and Barat Laut Selangor) had superior productivity per hectare compared to the other granaries. Nonetheless, in comparison to other rice-producing Southeast Asian countries, the average productivity of these granaries ranked third, after Vietnam and Indonesia.



It is noteworthy that Malaysia's overall paddy cultivation area is the lowest in Southeast Asia, including 0.70 million hectares. As to the United States Department of Agriculture (USDA), 2020, the leading rice producers in the region—Indonesia, Vietnam, and Thailand—have designated 11.50, 7.54, and 10.83 million hectares, respectively.

The agricultural sector in Malaysia is very potential; yet, it now has many challenges, one of which is a shortage of labor for farming. Severe weather conditions, insufficient supplies, and inefficient fertilizer application, along with infections, illnesses, allergies, and other health complications caused by chemical treatments (fungicides, pesticides, insecticides, etc.) or bites from insects or animals, provide further challenges. Drones have shown to be an effective method for rapid and non-invasive assessment of air quality, soil physical properties, and crop development, hence addressing several challenges in agriculture via the use of sustainable ICTs. Contemporary farmers encounter a multitude of intricate factors that influence the profitability of their enterprises, including water availability, varying growing seasons, wind, soil quality, and the prevalence of weeds and insects, among others. Consequently, farmers are using advanced drone technology to address these challenges swiftly and efficiently. Drones may collect data on several subjects, such as agricultural yields, animal health, soil quality, nutrient levels, meteorological patterns, and precipitation totals.

The knowledge acquired from this may thereafter be used to delineate issues more accurately and to formulate remedies grounded on robust facts.

Future environmental issues may arise from the heightened use of pesticides and fertilizers in agricultural techniques and the intensification of these methods. In a same vein, there exists a worldwide deficiency of farmers and restricted cultivable land. These challenges underscore the need for innovative and sustainable agricultural solutions [7,5,2,1]. An effective strategy for addressing these issues has been identified that integrates innovative technology. These talks have resulted in the advancement of smart farming [8,9,10] and precision agriculture [11].

LITERATURE REVIEW

Drone basic concept

The increasing use of tiny, unmanned aerial vehicles (UAVs), sometimes referred to as drones, in agriculture is a contemporary trend. Drones are remotely operated aircraft devoid of a human pilot.

These may significantly improve the collecting of geographical data and facilitate evidence-based planning in agriculture. These tools and technologies may provide valuable information that can subsequently influence policies and choices, despite some inherent limitations.

Drones are used across several sectors, including as agriculture, disaster response, and the military. A new revolution has started owing to the advantages that "an eye in the sky" provides when integrated with analytical tools capable of converting data and images into actionable insights. Nevertheless, the key to the sustained

acceptance of these technologies is to prioritize privacy, safety, and security concerns.

Drones are anticipated to profoundly transform agricultural practices over time. Precision agriculture can address the water and food concerns via the use of drone technology. Utilizing big data and GPS for crop management is referred to as precision agriculture. Drones have lately aided farmers in enhancing agricultural yield via their capabilities. Drones may ascend to 120 meters and collect, change, and analyze every leaf on a corn plant. They may also gather data on soil water retention capacity and variable-rate irrigation, offering agricultural information to farmers and agricultural advisors. The use of drones in agriculture is being advanced to assist both small and large-scale agricultural operations.

Drone and agriculture

The use of drones in agriculture and farming is evolving. Farms and agricultural enterprises may enhance crop yields, save time, and make informed land management choices that will improve long-term performance with the integration of drone technology.

Contemporary farmers encounter a myriad of intricate factors influencing the profitability of their enterprises, including water availability, several growing seasons, wind conditions, soil quality, and the prevalence of weeds and insects, among others. Consequently, farmers are using advanced drone technology to address these challenges swiftly and efficiently.

Agricultural drones enable farmers to get diverse data that facilitates improved management decisions, enhances crop yields, and increases overall profitability. Drones may collect data on several subjects, including agricultural yields, animal health, soil quality, nutrient evaluations, meteorological patterns, and precipitation totals. This knowledge may thereafter be used to delineate issues more accurately and formulate solutions grounded on robust facts. Agriculture has a history of embracing technology improvements to enhance operational efficiency. The latest technological advancement that will aid agricultural enterprises in addressing the evolving and increasing needs of the future is the use of drones in agriculture.

The UN has evaluated drone use in many sectors under its jurisdiction, including agriculture and humanitarian efforts. The World Food Programme (WFP) and the Belgian government have partnered to deploy drones in response to humanitarian crises. Field testing during tough humanitarian emergencies was essential in assessing the efficacy of drones for rapid data collection with enhanced precision and providing a safer monitoring system. Google and the FAO have collaborated to enhance the efficacy and accessibility of remote sensing data. Formulating effective policies and actions to achieve the Sustainable Development Goals by 2030 requires access to high-quality data. Drones are being used in agriculture, including agricultural productivity, early warning systems, disaster risk mitigation, forestry, fishing, and wildlife protection.

METHODOLOGY

The study performed 10 distinct interviews with paddy farmers in Selangor, mainly between Tanjung Karang and Sungai Besar, to get the ultimate output of the report. The interview lasted over two hours and was conducted twice with each farmer who purchased or operated DJI drones. The researcher performed all interviews with farmers using standardized techniques. All farmers involved in this study will be designated as participant '1' through participant '10'.

Regulations Related to Using Drones to Spray Pesticides

To use drones for spraying, two certifications are required from the FAA: a "Part 107 Certificate" for drone operation and a "Part 137 Certificate" for pesticide application via drones, or for pesticide application under the direct supervision of an individual possessing this license. Spraying pesticides in Ohio requires additional requirements beyond these two FAA certifications. An applicator is required to finish the Ohio Commercial Pesticide Category 1 training course, which addresses "the application of pesticides, excluding fumigants, via aircraft."

Operating Characteristics of Multi-rotor Spray Drones

The application rate of spray drones in row crops typically ranges from 1.5 to 2 gallons per acre. The rate is influenced by several factors, primarily the spray tank capacity, flight speed, spray swath width, number of nozzles or rotary atomizers on the drone, and the flow rate (volume dispensed per minute). A 5-gallon tank may need 2 to 3 minutes to deplete. Certain drones are equipped with a tank sensor to indicate the liquid level. The sensor may

be configured to halt spraying and return the drone to its home base when a tank refill is necessary. Upon replenishment, the drone returns to resume spraying at the point of interruption.

The maximum flight speed of multi-rotor drones ranges from 10 to 30 miles per hour. They are typically flown at an altitude of 7 to 12 feet above the ground or crop canopy. Forestry applications may need the drone to ascend above 30 feet above the ground to circumvent obstructions. All contemporary drone models are equipped with a terrain sensor that regulates the optimal flying altitude for spraying irregular and undulating landscapes, while autonomously maneuvering over hills and inclines.

Limitations of Spray Drones and Obstacles to Their Adoption

The adoption of spray drones by individual farmers has been gradual due to many factors. Insufficient research data exists comparing the performance of drones, including effectiveness and spray drift, to ground sprayers and conventional aircraft. The few published data about the performance of spray drones may be unreliable and perhaps contradictory because to the significant variability in design parameters across the drones evaluated. Fewer acres are treated per hour of operation in comparison to aerial and terrestrial sprayers.

Application of drones in agriculture

Drones may aid in gathering essential data during each phase of the agricultural cycle. We can assess potential soil quality, nutrient management, or soil dead zones by acquiring 3D maps of the current soil. Traditional methods include the physical collection of soil samples from selected locations to assess the soil's moisture content, nutrient deficiencies, and pest infestations, or using satellite remote sensing technologies [36]. While ground-based or satellite photography is more effective for optimizing variable rate applications like as nitrogen, phosphorus, and potassium, these methods need significant time, financial resources, and effort. Unmanned Aerial Vehicles equipped with thermal imaging technology may be used to assess the soil's moisture levels. Uniformly dispersing fertilizer, rather than determining application locations and quantities based on plant density and health, may save costs and mitigate soil contamination, since crops can never grow precisely equally. Enhancing the precision of the Variable Rate Application method reduces costs and increases crop yield. Drone-generated variable-rate application (VRA) maps facilitate the determination of the amount and quantities of chemicals to be applied in a specific area. The drone platform may signify a novel framework for policymakers and management professionals in forecasting agricultural output and production or formulating long-term plans to address adverse conditions.

Assessed the production and total biomass of a rice crop with low-altitude remote sensing from an unmanned aerial vehicle. The LARS - UAV platform may substitute costly satellite-based and airborne remote sensing technologies for estimating yield and biomass in relation to nutritional status in rice. Time-series agricultural production maps may be constructed with data on farm biophysical features, management strategies, and socioeconomic variables. Analyzing the matrix will facilitate the identification of underlying causes of difficulties and the presentation of pragmatic solutions to enhance agricultural output and the general welfare of the farming community. Statistical models for risk management may be developed using historical yield, pest, and climate data.

It may serve as an effective instrument for strategizing post-harvest management techniques and for the early detection, forecasting, and alerting of pest infestations. Agriculturists may use this information to ascertain optimal procedures for planting, crop management, soil management, and other operations. Ongoing monitoring may facilitate the more effective regulation of crop nutrient levels and enhance the usage of water resources.

Seed planting

Although it is a more newer and less used technology, several enterprises are experimenting with drone planting. Producers are innovating with specialized equipment designed to launch seed pods into prepared soil. Startup drone enterprises have significantly contributed to the development of novel drone technology to address different ecological and agricultural challenges. Contemplate Drone Seed. Drone technology may be adapted and used across many agricultural sectors, reducing labor costs and total planting durations.

Crop spraying and spot spraying

This is the most critical phase in the life cycle of a crop. Continuous fertilization and application of pesticides are essential for crops to maintain good yields.

Historically, this was done manually, using automobiles or, in some regions, an aircraft. These treatments may be very costly, as well as unsuccessful and burdensome. Drones may be equipped with large reservoirs containing pesticides, herbicides, or fertilizers. The use of drones for crop spraying is much safer and more cost-effective. Fully autonomous drone operations are feasible, and they may be programmed to adhere to specified routes and timetables.

Drones can do more advanced, precise, and focused operations than those previously stated. Consequently, their applications are not limited to those specified. It may be used to apply protectants efficiently. Drones may be used for "search and destroy" pest control activities, which include identifying and eradicating especially troublesome insects.

Canada used the first aerial pesticide application to address forest insect issues. Calcium arsenate was used to prevent the spruce budworm (*Choristoneura fumiferana*) from defoliating forest stands. The first remote-controlled aerial spraying device was developed in 1980. The RMAX, R50, KG-135, YH300, and YH3 from Yamaha were designed for the application of pesticides on agricultural yields like rice, soybeans, and wheat. Miller (2005) conducted an experiment to evaluate the effectiveness of using a UAV for pesticide application to reduce insect-related human illness. A series of tests were undertaken to assess the efficacy of the UAV for aerial pesticide application, using a commercially available Yamaha RMAX UAV outfitted with both liquid and granular pesticide dispersion mechanisms.

Crop mapping and surveying

One of the primary advantages of drone technology is its capacity for efficient surveillance of extensive agricultural fields and land regions. Historically, satellite or aerial imaging was used to provide a comprehensive overview of farms and detect possible issues. Moreover, apart from their high cost, these photos were deficient in the precision that drones can provide. Currently, real-time video and time-lapse animation are available to illustrate crop progress instantaneously. Drone mapping and surveying enable technological choices to be grounded on real-time facts instead of outdated images or conjectures. The representation of crop data in GIS is improved by a three-dimensional (3D) visualization of a field, offering more information to facilitate the automation of agricultural tasks. High-definition, geographically accurate 3D elevation models and maps of the fields may be generated using images captured by the drones' high-resolution cameras and laser scanners. The gathered photographs are converted into point clouds, which may then be used to create maps [43,44]. These maps may be used to assess volume, construct irrigation and drainage systems, and administer chemicals. Data may be obtained from agricultural drones, including overall crop and plant health, land distribution by crop type, crop life cycle, and precise GPS mapping. Drones may be used to monitor and analyze animal behavior and movement. A UAV can assess a cow's body temperature with temporal sensors to detect sickness at an early stage. They may also be used to observe agricultural regions at nighttime. Drone survey photographs may be used to create detailed maps of forest cover and assess tree height. They may also be used to identify and extinguish forest fires. Drones facilitate the identification and assessment of illegal mining, wildfires, deforestation, and oil spills that threaten the lives of forest communities. Without the risk of promptly apprehending criminals, they may also identify camps and routes frequented by trespassers, including unauthorized hunters, .

RESULTS

Time and cost savings

One of the main benefits for farmers is that numerous duties may be accomplished more efficiently due to smart technology. Drones significantly surpass human aircraft in time efficiency for operations such as mapping, surveillance, and agricultural spraying. Moreover, drones may be used to sow seeds and apply water, fertilizers, insecticides, and herbicides to crops.

As several jobs may be executed using intelligent aerial modes, farmers can save expenditures on labor and equipment due to decreased time spent in the field.

Table1. Drone spraying case study data table

| Specification | Value |
|---------------------------|------------------------|
| Spraying Rate | 7.5 L/min |
| Max Pressure | 1.2 Mpa |
| Tank Capacity | 15 L |
| Spray Gap | 0.9 m |
| Boom width | 2.65 m |
| Flight time (herbicide) | 2.5 min (at 50% flow) |
| Flight time (fertilising) | 1.3 min (at 100% flow) |

Table 2. Drone spraying datasheet table

| Specification | Hollow cone (Herbicide) | Flat spray (Fertilizer) |
|-------------------------------------|----------------------------|---------------------------|
| Spray angle | 80° | 110° |
| Pressure range (recommended) | 2-20 Bar (0.45-1.62 L/min) | 2-6 Bar (0.45-0.75 L/min) |
| Spray gap (recommended) | 0.35 m | 0.5 m |
| Spray height (from top of the crop) | 0.75 cm | 0.75 cm |

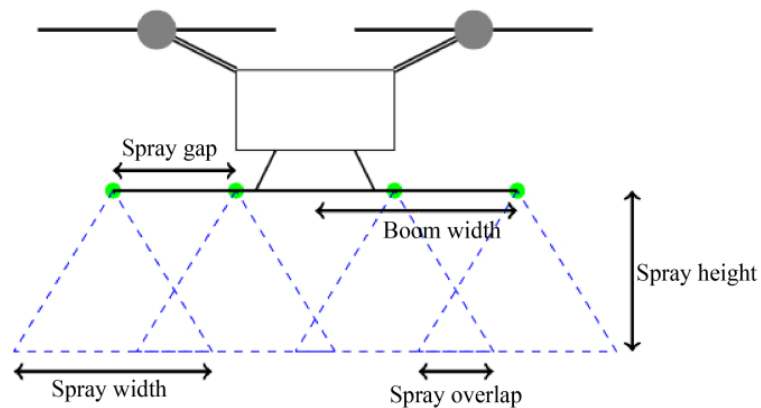


Fig. 1 Drone spray configuration, A-boom length, B-spray gap, C-drone height, D-spray width, E-spray overlap

Participant 2 said, “Previously, utilizing a blower required approximately 50 minutes to one and a half hours for a 3-acre area; now, employing a drone reduces this time to about 20 minutes.” Participants 1, 3, 4, 6, and 7 corroborated this, saying that “utilizing a blower typically requires one to one and a half hours, whereas employing a drone significantly reduces the duration to merely 20 to 30 minutes per task.” Participants 2, 8, 9, and 10 said that using drones for pesticide application takes around 10 to 15 minutes. This is due to their existing proficiency in operating drones. According to , drones are used to apply pesticides to mitigate the dissemination of agricultural diseases, enabling the spraying of herbicides and insecticides on a field in around 30 minutes or less. Typically, using a drone may reduce the time required for a rice field by around 40 to 45 minutes. Drones provide significant cost reductions, particularly in the use of water, herbicides, and insecticides. All participants said that "a rice field typically requires 145 liters of water and 500 ml of pesticide when utilizing a

blower, whereas employing a drone necessitates only 45 liters of water and 60 ml of pesticide." This demonstrates considerable savings attributable to the drone's more efficient and uniform application. Utilizing a blower consumes significant amounts of water and pesticides, as noted by participants 2, 5, and 6, who said, "Using a blower incurs high costs in water and pesticides due to the slow movement of the operator and the zig-zag pattern of the spray." Water for irrigation is one of the most precious commodities in the agricultural sector. The use of drones in irrigation systems may facilitate effective water distribution in rural regions while minimizing water wastage. Furthermore, it can identify the determinants that contribute to water waste.

Safer way to spray the crop

Agriculturists must constantly contend with pests and plant diseases, and the manual application of pesticides to crops is time-consuming, labor-intensive, and detrimental to health. Employing drones for the treatment of diseased plants is much safer and more efficient than manual work and the use of terrestrial machines. Intelligent drones include autonomous flying capabilities, enabling farmers to design flight trajectories specifically for areas necessitating treatment, while preserving the healthier sections of the field from chemical exposure.

Farmers will economize by refraining from treating plants that do not need intervention, so making this crop treatment strategy safer overall.

In Malaysia, farmers encounter the issue of bacterial leaf blight (BLB). This illness is induced by *Xanthomonas oryzae* PV. These diseases substantially affect global rice production.

Bacterial leaf blight, often referred to as *Xanthomonas oryzae* pv *oryzae* (Xoo), is a lethal disease impacting rice (BLB). Currently, 42 R genes provide protection to rice, and this figure is increasing. Owing to the coevolution and selective pressure between Xoo and rice, certain Xoo strains or races, which include collections of strains exhibiting incompatibility with defined sets of R genes, demonstrate selected resistance to these R genes. *Oryzae* is considered the most consequential and primordial disease impacting rice. Japanese agriculturists identified this affliction for the first time in 1884. The infection was first identified on a limited scale in rice fields in Peninsular Malaysia during the early 1980s. Historically, this disease disseminated more rapidly, leading to 10–20% crop losses under moderate circumstances, although losses of up to 50% were recorded under optimal conditions. In the 12,080-hectare rice cultivation areas of Peninsular Malaysia, including Selangor (5,945 ha), Kedah (4,415 ha), Pulau Pinang (620 ha), Terengganu (440 ha), Negeri Sembilan (291 ha), Perak (174 ha), Pahang (46 ha), Perlis (141 ha), Johor (5 ha), Kelantan (1 ha), and Melaka (less than 1 ha), there has been a rise in bacterial leaf blight incidents.

BLB induces moderate to severe infections and virtually intrudes onto Malaysia's main rice cultivation areas. This may result in the complete failure of the field's crop. The problem may manifest in all stages of the plant, including the seedling, vegetative development, and reproductive phases, since it is a vascular disease. The disease may spread rapidly by the transportation of plant straw, precipitation, hail, wild rice, wind, weeds, irrigation water, and seeds [57]. Bacterial inoculum infiltrates host plants via wounds, lesions, or hydathodes in the leaf, thereafter advancing through the plant's xylem layer by layer.

All participants said that "the dissemination of BLB occurs via humans traversing rice fields." Primarily for those who continue to use blowers for pesticide application, the introduction of drones in the region has emerged as a beneficial answer for rice producers. Participant 2 said, "Drones are easy to use." BLB illnesses do not adhere to our bodies. Participants 6 and 7 said, "the utilization of drones allows us to avoid entering rice fields affected by BLB disease, thereby preventing its dissemination to other regions." Another participant noted that rice farmers not only cultivate their own fields but also labor in other rice fields. Therefore, it is necessary to enter in order to apply pesticides, assuming a blower is used. With the use of drones, rice farmers are no longer need to access the fields, so indirectly facilitating the management of the BLB disease's proliferation.

CONCLUSION

The remarkable progress of drone technology significantly influences several aspects of modern life, transforming personal experiences and commercial operations. The agriculture industry has embraced drone technology, using these advanced technologies to transform contemporary farming practices. Agriculturalists and the drone operators who pilot them may enhance some aspects of the agricultural process via the use of advanced drones. Drones enhance several tasks, such as agricultural monitoring, planting, livestock management, crop spraying, and irrigation mapping. Drones are advantageous for paddy agriculture in monitoring, measuring, and making

choices based on real-time crop and animal data. Eliminating guessing in contemporary agriculture allows farmers to optimize their paddy fields, enhance business management, and augment crop yield. Drone technology presents numerous features, capabilities, and facilities that could lead to significant technological advancements, particularly in agricultural applications. This paper aims to enlighten researchers, paddy farmers, local authorities, and others to promote and motivate the agricultural sector, especially in paddy cultivation, to leverage the benefits of drones to enhance future paddy production.

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