Madras Agric.J.,2025; https://doi.org/10.29321/MAJ.10.70JE25

RESEARCH ARTICLE

Knowledge Gain of Farmers in Drone Applications in Agriculture through Demonstrations

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Received: 11 Apr 2025

Revised: 27 Apr 2025

Accepted: 03 May 2025

ABSTRACT

Chemical pesticides are often used to protect crops from pest and disease outbreaks to increase crop yield. Drone spraying helps in mass spraying during severe pest and disease outbreaks. The present study focused on knowledge gain regarding drone applications in agriculture, conducted in the Cuddalore district in 2024. By using simple random and purposive sampling methods, 120 demo farmers were selected from 16 villages in four blocks of Cuddalore district. Through the Krishi Vigyan Kendra, Cuddalore conducted trainings and demonstrations in different field crops covering an area of 500 acres, along with Department officials, during 2022-2024.Knowledge level and Knowledge gain percentage formulae were used to analyze the recorded data. The study inferred that the percentage of knowledge possessed by the area farmers was higher for the spraying of fertilizers and agrochemicals, followed by irrigation scheduling of crops and sowing and planting using drone applications. The highest knowledge gain percentage was recorded for pest and disease monitoring (71.67), sowing and planting (71.17), nutrient disorders (67.83), and irrigation scheduling of crops (63.33), as the farmers in the study area were not aware that drones can be utilized for these purposes. The primary constraints faced by farmers in adopting drone technology in agriculture were High cost, Lack of Knowledge and skills, Internet connectivity issues, Scarcity of Trained Pilots, and Techno-Economic Feasibility. Farmers expressed a positive attitude towards the efficiency and precision of drones in reducing labour and time spent on manual tasks in farming operations. However, challenges need to be overcome by government initiatives and schemes to enhance the acceptance and application of drones for sustained farming and rural livelihoods.

Keywords: Drone technology, Knowledge gain, Crop yield, Constraints

INTRODUCTION

In developing countries like India, more than 70% of the population depends on agricultural fields for their livelihood. Under natural conditions, both agricultural and horticultural crops face significant yield losses due to pest and disease outbreaks, affecting crop productivity. Chemical pesticides are often used to protect crops from pests and diseases, and to increase crop yield. According to the WHO

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(World Health Organization) estimate, approximately one million people were seriously affected by manual pesticide spraying, posing a serious threat to the agricultural labourers involved in spraying work.

In the technological world, with rapid advancements in science, many developments are happening around the world to enhance crop productivity and reduce human effort. One such invention is the unscrewed aerial vehicle (UAV) aircraft developed for spraying pesticides on crops. A typical UAV is an aircraft that can fly without a human pilot and is controlled by a radio channel. In recent times, pesticide spraying UAVs have been developed, which consist of an automated drone system and a sprinkling system. The UAV sprinkling system auto-navigated using GPS coordinates to spray pesticides on the required areas or crops. The sprinkling system is attached to the lower region of the UAV, which has a nozzle beneath the pesticide tank to sprinkle the pesticide downward onto the crop canopy. Spraying drones with multi-spectral cameras are also available in the market; these are capable of monitoring the field and generating spatial maps. These maps show the exact conditions of the crop, allowing agricultural operations (e.g., pesticide/herbicide/ nutrient spraying) to be carried out accordingly. These technologies are useful where human interventions are not possible for spraying chemicals on crops, one of the main reasons being the scarcity of labor.

Chamuah & Singh (2019) suggested that in the governance of emerging technologies like UAV, specific values, such as trust, transparency, safety, autonomy, and environmental friendliness, assumed high significance. They also noted that UAVs have the risk-taking ability in adverse weather conditions. The UAV technology also creates value (social, economic, and environmental) for deployment in the crop insurance business in India.

Unmanned aircraft systems (UAS), commonly referred to as drones, are an emerging technology that has changed the way many industries conduct business. Precision agriculture is one industry that has consistently been predicted to be a significant locus of innovation for UAS. However, this has not been the case globally. The agricultural aircraft sector in the United States is used as a case study to consider different metrics for evaluating UAS adoption, including a proposed metric: the normalized UAS adoption index. In aggregate, UAS operators only make up 5% of the number of agricultural aircraft operators. However, the annual number of new UAS operators exceeded that of manned aircraft operators in 2022. When used on a state-by-state basis, the normalized UAS adoption index reveals regional differences in UAS adoption, with western and eastern states exhibiting higher UAS adoption rates, while central states have significantly lower rates. This has implications for UAS operators, manufacturers, and regulators as this industry continues to develop at a rapid pace. (*Rodriguez, 2023*)

Drones in Indian Agriculture

The marginal and small farmers constitute 78.2 per cent of the farming community in India. Although tremendous technological advances have been made in various fields in India, agriculture is still lagging in the large-scale adoption of technologies. However, the use of drones in the agriculture industry is steadily growing for sustainable agriculture. the use of drones can be advantageous in the case of pesticide spraying, replacing labour-intensive and hazardous conventional methods, particularly in difficult areas such as hills, and to carry out synchronized spraying in places where pest and disease outbreaks damage the crops heavily. Timely actions can also be taken to prevent losses from biotic stresses.

Limitations in manual sprayingincludes Lesser efficient cum labour-intensive, Low precision with risk of pesticide poisoning to human beings, more pesticide and water wastage, increased cost on agro chemicals leading to soil and water pollution and synchronized spraying is not possible.

Advantages of Drone Spraying

Human health safety: Agriculture sprayer drones are remotely controlled from a distance by trained personnel. Therefore, the direct involvement of farmers or farm labourers with poisonous chemicals is avoided.

Agrochemical savings: Approximately 30% of agrochemicals/pesticides are saved due to the high degree of atomization achieved during spraying. Pesticides in the form of chemical fog can be sprayed at all stages of the crop.

Water conservation: The drone utilizes ultra-low volume spraying technology, saving up to 90% of water compared to traditional spraying methods.

Lower cost: The cost of spraying is reduced by 85-

90% with drones, compared to conventional spraying methods.

High field efficiency and coverage:A drone can spray 50-100 acres per day, depending on the capacity of the drone, which is 30 times more than a traditional knapsack sprayer.

Synchronized spraying: Drone spraying facilitates mass spraying during severe pest and disease outbreaks.

Easy to handle and maintain: It has low maintenance cost, a long productive lifespan and its parts replacement is simple.

Social distancing: Drone technology can save labor and also help maintain social distancing norms during the COVID-19 pandemic.

Dutta & Goswami (2020) concluded that Drones provide real-time and high-quality aerial imagery compared to satellite imagery over agricultural areas. Additionally, applications for localizing weeds and diseases, determining soil properties, detecting vegetation differences, and producing accurate elevation models are currently possible with the help of drones. Drones will enable farmers to gain a deeper understanding of their fields. Therefore, farmers will beassisted with producing morefood while using fewer chemicals. Nearly all farmers who have used drones have achieved some form of benefit. They can make more efficient use of their land, exterminate pests before they destroy entire crops, adjust the soil quality to improve growth in problem areas, improve irrigation to plants suffering from heat stress, and track fires before they get out of control. Therefore, drones may become an integral part of agriculture in the future, helping farmers manage their fields and resources more effectively and sustainably.

Rana & Mahima (2020) concluded by recommending that more farmers adopt drone techniques to improve their agricultural outcomes, and considering recent research trends to employ agricultural UAVs, control technologies, and equipment development is essential.

To popularize drone spraying and make it available locally, the field extension functionaries working in Krishi Vigyan Kendras (KVKs) need to be trained and oriented towards popularizing drone usage through field demonstrations of various agricultural applications. Secondly, drone sprayer is to be made available at KVK, Vriddhachalam, Cuddalore district. The KVK will effectively monitor field situations and recommend when drone spraying is necessary. The drone will be hired to farmers along with technical personnel, and the fee thus collected will be used for drone sprayer maintenance. Method demonstrations and training sessions on drone spraying will be provided to stakeholders.

MATERIALS AND METHODS

Through the two drone schemes *viz.,* Empowering farmers through drone system for Precision Agriculture in Cuddalore district funded by NABARD, Chennai, and ICAR ATARI Hyderabad funded Agricultural Drone Project in 250 ha at KVK, Vriddhachalam, Cuddalore for a period from 2021 to 2023, KVK covered all the 14 blocks of Cuddalore district in imparting training and demonstrations in both agricultural and horticultural crops. Until March 2023, KVK has conducted various awareness programs, trainings, and demonstrations in different field crops, covering an area of 500 acres and reaching about 600 farmers, including Department officials.

The two drones will be maintained at the KVK, Vriddhachalam, and will be hired to farmers on a rental basis, so that small and marginal farmers will benefit from the project. The income generated through the collection of hiring charges will be used to cover the operational cum other recurring expenses of drone sprayer. For farmers, the cost-benefit of drone spraying will be calculated after the crop is harvested. Apart from these, the environment is preserved due to the reduced use of pesticides over a large area in a synchronized manner. This will also help in the buildup of natural enemies (predators, parasites, etc.) in the agroecosystem, thus making the plant protection measures very effective.

Topic of the trainings	No. of programmes	Total participants
Awareness creation to farmers and Extension officials	1	250
Training on Drone system-Operation, pesticide application and maintenance	3	130
Field demonstration of drone spraying	6	205

The use of drones in the industry is steadily growing for sustainable agriculture, and the study focused on gaining knowledge about drone applications in agriculture conducted in the Cuddalore district. By using the simple random and purposive sampling methods, 120 demo farmers were selected from 16 villages in four blocks of Cuddalore district, namely Nallur, Mangalur, Kammapuram, and Vriddhachalam. Transfer of technology holds the key to the rapid development and transformation of rural society. The Krishi Vigyan Kendra, Cuddalore, has conducted various awareness programmes, trainings, and demonstrations in different field crops, covering an area of 500 acres and reaching about 600 farmers, along with Department officials, during 2022-2024.

A structural questionnaire was prepared, consisting of 15 questions on various aspects of drone application in agriculture. The questionnaire was used for pre- and post-training tests with the same set of questions, and subsequently, data were collected. A score of '1' for correct response and '0'score for incorrect response was given for analysis of the Knowledge level of farmers in each aspect, and the gain in knowledge was calculated. A simple percentage calculation was performed to analyze the knowledge level and knowledge gain.

The following formulae were used for evaluation (*Chakraborty et al., 2022*):

$$\text{Knowledge \%} = \frac{\text{Score obtained}}{\text{Possible obtainable score}} \times 100$$

Knowledge Gain % = (Score obtained on PDE - Score obtained on PoDE / Total possible obtainable score) x 100

*Pre-demonstration evaluation (PDE) and Post-demonstration evaluation (PoDE)

Table 1. Knowledge level of farmers of Cuddalore district on various aspects of drone application in agriculture (n=120)

S.No.	Knowledge items on drone application	Knowledge score obtained on		Knowledge % on		Knowledge gain%	Rank
		Pre demonstration evaluation (PDE)	Post demonstration evaluation (PoDE)	Pre demonstration evaluation (PDE)	Post demonstration evaluation (PoDE)		
1	Spraying of fertilizers and agro chemicals	78	117	65.00	97.50	52.00	7
2	Irrigation scheduling of crops	56	110	46.67	91.67	63.33	4
3	Sowing and planting	31	97	25.83	80.83	71.17	2
4	Pest and disease monitoring	16	85	13.33	70.83	71.67	1
5	Nutrient disorders	11	77	9.17	64.17	67.83	3
6	Soil and field analysis	9	65	7.50	54.17	57.50	5
7	Water stress monitoring	8	59	6.67	49.17	52.33	6
8	Crop yield estimation	5	52	4.17	43.33	47.83	8
9	Disaster management	4	49	3.33	40.83	45.67	10
10	Crop monitoring and health management	6	45	5.0	37.50	40.00	12
11	Evapotranspiration	3	42	2.50	35.00	39.50	13
12	Weed identification and weeding	4	40	3.33	33.33	36.67	14
13	Geo fencing	3	38	2.50	31.67	35.50	15
14	Crop biomass and damage estimation	2	44	1.67	36.67	42.33	11
15	Livestock management	4	51	3.33	42.50	47.67	9

Table 2. Knowledge gain farmers of Cuddalore district on various aspects of drone application in agriculture

S.No.	Knowledge items on drone application	Knowledge gain %	Rank
1	Pest and disease monitoring	71.67	1
2	Sowing and planting	71.17	2
3	Nutrient disorders	67.83	3
4	Irrigation scheduling of crops	63.33	4
5	Soil and field analysis	57.50	5
6	Water stress monitoring	52.33	6
7	Spraying of fertilizers and agro chemicals	52.00	7
8	Crop yield estimation	47.83	8
9	Livestock management	47.67	9
10	Disaster management	45.67	10
11	Crop biomass and damage estimation	42.33	11
12	Crop monitoring and health management	40.00	12
13	Evapotranspiration	39.50	13
14	Weed identification and weeding	36.67	14
15	Geo fencing	35.50	15

Table 3. Constraints faced by farmers in adoption of drones in agriculture (n=120)

S.No.	Constraints	Number	Percentage
1	High Cost	120	100.00
2	Knowledge and Skill	113	94.17
3	Internet Connectivity Issue	110	91.67
4	Scarcity of Trained Pilot	109	90.83
5	Techno-Economic Feasibility	105	87.50
6	Limited Flight Time and Range	98	81.67
7	Weather Dependency	95	79.17
8	Safety and User-Friendliness	92	76.67
9	Issue of Long Term Profitability and Operational Cost	89	74.17
10	Regulatory Uncertainty in pesticide spraying	87	72.50

RESULTS AND DISCUSSION

From the study (Table 1) it is concluded that knowledge percentage possessed by the area farmers were higher for Spraying of fertilizers and agro chemicals (97.50), Irrigation scheduling of crops (91.67) and Sowing and planting (80.83) about drone application uses and gradually declined for other uses of drones application, as the leading farmers in the study area were using drones in these aspects.

The study revealed that highest knowledge gain percentage in terms of drone application in agriculture (Table 2) was recorded for Pest and disease monitoring (71.67) followed by Sowing and planting (71.17), Nutrient disorders (67.83) and Irrigation scheduling of crops (63.33) as the farmers in the study area were not aware that drones can be utilized for these purposes too.The farmers gained knowledge on the application of drones, which can be used for Soil and field analysis (57.50), Water stress monitoring (52.33),

and spraying fertilizers and agrochemicals (52.00), as these applications were already known to farmers through their field usage.

The farmers in the study area also gained knowledge in new aspects of drone application- in agriculture, such as spraying fertilizers and agrochemicals, Crop yield estimation, Livestock management, Disaster management, Crop biomass and damage estimation, Crop monitoring and health management, Evapotranspiration, Weed identification and weeding, and geofencing.

Similar findings were reported by Prachi et al. (2024), who found that more than two-thirds (68.21 percent) of progressive farmers had a low level of awareness of drone technology application, while the remaining 31.79 percent had a very low level of awareness. *Katekar & Cheruku (2022)* demonstrated that map-based optimized nitrogen application using drones resulted in a 20% reduction in nitrogen input. The reduction in input costs of agrochemicals (pesticides and weedicides) is estimated at around 25-30% due to automated processes.

The study by *Katekar and Cheruk (2022) found that the application of drone technology saves time, labor, water, and reduces* spending on chemicals. It also reduces the use of chemicals and eliminates chemical exposure to humans. The paper concludes that the government should effectively adopt and leverage the potential of drone technology to transform the agricultural sector and the lives of millions of farmers in India.

The first five significant constraints (Table 3) faced by farmers in adopting the drone technology in agriculture wereHigh cost (100%), Knowledge and skill (94.17%), Internet connectivity issue (91.67%), Scarcity of Trained Pilot (90.83%) and Techno-Economic Feasibility (87.50 %). The other constraints were Limited Flight Time and Range, Weather Dependency, Safety and User-Friendliness, Issues of Long-Term Profitability and Operational Costs, and Regulatory Uncertainty in pesticide spraying. Due to these challenges, farmers were unable to utilize drones for all the new aspects of agricultural applications.

Farmers expressed a positive attitude towards the efficiency and precision of drones in reducing labour and time spent on manual tasks in farming operations. Still, challengessuch as the durability of drones in extreme weather conditions, connectivity issues in rural areas, and maintenance costs need to be overcome by government initiatives and schemes in enhancing the acceptance and application of drones for sustainable farming and rural livelihoods.

CONCLUSION

Drone technology is an excellent and innovative technology capable of transforming traditional manual activities in agriculture. However, the high cost of drones and the limited availability of technically trained personnel (known as pilots) are the major hurdles in the use of drones in agriculture. Due to the high costs associated with purchasing drones, small and medium-scale farmers are often reluctant to adopt them. Hiring a drone with technical personnel is also highly expensive, even for large farmers. If drone spraying is to be practiced by farmers, drones should be made available locally, along with trained personnel for custom hiring. Otherwise, the farmers may be encouraged to form an enterprise and purchase their drones.

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