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Drone-Based Spraying in Rice: A Smarter Way to Manage Insect Pests

Rittik Sarkar[1*], Rajna S[2], Rohit Raman[1], Poulami Bhattacharya[3] and Smriti Manna[4]

[1]Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005, Uttar Pradesh, India.
[2]Division of Entomology, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India.
[3]Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar 751003, Odisha, India.
[4]Department of Plant Pathology, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur 848125, Bihar, India.

Corresponding Author
Rittik Sarkar
Email: rittikrnj197@gmail.com

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ABSTRACT

Farmers have sprayed rice fields by hand for generations, and for good reason: it is cost-effective and does not need much equipment. But walking through standing water with a knapsack sprayer strapped to your back is slow work, and once the canopy thickens up, getting even coverage becomes a significant challenge. Unmanned aerial vehicles (UAVs) are changing that picture. UAV carries its own spray tank, follows a route the operator sets in advance, and releases a fine mist over the crop without anyone needing to set foot in the mud. Get the flight height, speed, nozzle choice, spray volume and weather right, and the deposition and pest control can be genuinely impressive, all while cutting down on labour and the physical toll of walking through a dense crop. However, a drone is not a wholesale substitute for the sprayer already in the shed. Cost is steep at the outset, pilots need real training, rules vary by region, batteries run out faster than anyone would like, wind complicates things, and dense lower canopies can still hide pests from an aerial spray pattern. Where this technology is headed next is toward smarter operators, better spray

hardware, and drones working alongside sensors and decision-support tools rather than standing in as a stand-alone fix.

INTRODUCTION:

Rice feeds more people than almost any other crop on the planet, which is exactly why insect damage to it matters so much. Planthoppers, stem borers, and leaf folders each show up at a different point in the crop life, and each can force a farmer's hand toward insecticide (Seni *et al*., 2022). But choosing the right chemical is only half the job. The other half is getting it to land where it is actually needed, in the right amount, at the right time. It is often where things go wrong with a knapsack sprayer: once a field turns to mud, or the crop grows tall and thick, walking it row by row becomes exhausting and uneven. This is the gap drone spraying is stepping into. Strip away the jargon and a spraying drone is really just a flying sprayer, one that carries its chemical load along a pre-set route and lays down droplets over the crop while the operator stays dry on the bund.

How Does a Spraying Drone Work?

Open one up and one will find a flight controller, a battery, a spray tank, a pump, some tubing and a set of nozzles, nothing exotic. Before take-off, the operator marks out the field boundary and plots the flight path. The drone then holds a set height and speed while its spray system pushes droplets out through the nozzles below. Since it never has to move through the standing crop itself, it turns out to be particularly handy in flooded rice fields, or anywhere that walking through would mean bruising or breaking plants underfoot. Boiled down, the whole operation comes to four steps: map the route, calibrate the sprayer, hold the right height and speed in flight, and keep an eye on the weather the whole time.

Why is Drone Spraying Attractive for Rice?

Figure 1. How drone-based insecticide spraying works in rice: from field mapping to pest suppression.

What makes UAV spraying worth a second look is the chance to pair timely application with much finer control over how that spray actually goes down. Researchers have found that once the operating conditions are dialled in, UAV applications can achieve solid droplet deposition alongside strong pest control (Zeng *et al*., 2025). Field trials on planthoppers back this up: properly tuned UAV settings have delivered noticeably good suppression (Huang *et al*., 2023). There's also a labour-saving benefit. Fewer trips through the field mean less time spent walking between rows and less physical damage to the crop. A drone can cover the field from above, reducing the need for repeated movement through the standing crop.

The "5 Key Settings" that Decide Spray Performance

1. **Flight height:** How far the nozzles sit above the crop shapes spread, penetration, and drift all at once. Fly too high and off-

target movement creeps up; fly too low and coverage suffers (Koo *et al*., 2024), along with a few operational headaches besides.

2. **Flight speed:** Push the drone faster and the spray gets less time to settle over any given patch of crop. Speed has to be balanced carefully: too fast leaves gaps (Wang *et al*., 2026), too slow wastes time and risks overlap.

3. **Nozzle type and droplet size:** The nozzle decides how the spray breaks apart into droplets. Finer droplets tend to cover better but drift more easily (Martins *et al*., 2021) when conditions are not cooperating, so nozzle choice needs to match the crop, the target pest and the weather on the day.

4. **Spray volume:** UAVs typically work with far less liquid per hectare than a ground sprayer would use (Bonds *et al*., 2024). That is efficient, but it also raises the stakes on calibration; there is less margin for error when droplet distribution has to carry more of the load.

5. **Weather conditions:** Wind, temperature and humidity all push droplet behaviour around (Chen *et al*., 2021). Spraying on a day that favours drift, fast evaporation or weak deposition tends to undo whatever the equipment was set up to do.

Can Drones Reduce Pesticide Use?

Perhaps the strongest case for drone spraying comes down to efficiency of application. A drone sticks to the area it is told to cover and lays down a prepared spray evenly along its route. Several studies point to real reductions in how much pesticide gets applied under UAV systems, though how much depends heavily on the crop, the formulation, the pest being targeted, spray volume and how the operation is run (Deng *et al*., 2024). Worth remembering here: "less spray" is not the same thing as "spray that works less well." The real target is placing the correct dose exactly where it's needed, not just squeezing the total volume down as far as it will go.

What about the Environment?

Precision spraying holds real promise for cutting down pesticide that drifts beyond where it is supposed to go. But a drone by itself does not guarantee an environmentally sound application—far from it. Bad calibration, heavy drift, unsuitable weather or the wrong nozzle can still send chemical where it should not go, drone or no drone (Wang *et al*., 2018). Water-sensitive paper and similar sampling tools offer a practical way to check whether droplets are actually landing on the crop as intended (Ahmad *et al*., 2022). The environmental payoff of UAV spraying, in the end, comes down to how well it is operated not to the aircraft sitting in the shed.

Limitations and Practical Challenges

None of this comes free of complications. The upfront cost puts a real dent in the budget of an individual smallholder (Nazarov *et al*., 2023), and flying one of these safely takes proper training, not a weekend of tinkering (Delavarpour *et al*., 2023). Battery life caps how long a drone can stay in the air, which means multiple batteries and a charging setup for anything beyond a small plot (Vijayakumar *et al*., 2025). Getting spray down into the lower, denser part of a rice canopy remains a stubborn problem; coverage on exposed leaves can look great while pests tucked lower in the plant go untouched (Cao *et al*., 2021). Weather can flip within hours, so a setting that worked perfectly yesterday might underperform today (Grant *et al*., 2022). There are also rules to follow, since agricultural drone operation is regulated, and those regulations differ by location (Delavarpour *et al*., 2023). And cost comparisons are not one-size-fits-all: whether a UAV pays off economically depends on field size, how much labour is available locally, and how often spraying needs to happen (Testa *et al*., 2025).

Table 1. Conventional knapsack spraying versus UAV-based spraying in rice

Feature	Knapsack spraying	UAV spraying
Labour	Operator walks through the field carrying the sprayer (Nag & Nag, 2004)	One operator controls the UAV remotely (Sánchez-Fernández *et al*., 2025)
Field movement	Walking between/through crop rows (Wong & Brown, 2020)	Flies above the crop; little or no crop trampling (Sassu *et al*., 2024)
Spray path	Operator-directed, less systematic (Wong & Brown, 2020)	GPS/planned parallel flight paths (Sarri *et al*., 2019)
Coverage	Depends strongly on operator movement and technique (Spencer & Dent, 1991)	More uniform application possible (Andryan *et al*., 2025)
Operator exposure	Higher (Yan *et al*., 2021)	Reduced direct exposure during application (Kuster *et al*., 2023)
Wet-field operation	Difficult in muddy/standing-water conditions (Wong *et al*., 2023)	Particularly useful where field movement is difficult (Quan *et al*., 2023)
Limitations	Labour-intensive and time-consuming (Rahman *et al*., 2025)	Battery/payload limitations, weather sensitivity, regulations, and higher equipment cost (Delavarpour *et al*., 2023), (Castaldo, 2023)

The Future: From Drone Spraying to Smart Pest Management

Where this technology goes next is not really about flying farther or carrying more chemicals. It is about spraying smarter. Drone platforms are already starting to link up with digital maps, sensors, imaging systems and data-driven decision tools (Filho *et al*., 2019). In the future, a drone might spot the patches of a field under heavier pest pressure, mark out a treatment zone on its own, and adjust the application to match. Bring in artificial intelligence, remote sensing and variable-rate spraying, paired with solid field scouting and integrated pest management, and the precision only sharpens further. The systems that end up working best will treat the drone as one piece of a larger pest-management strategy, not as a replacement for sound agronomy, but as one more tool inside it.

CONCLUSION

Drone spraying is opening a genuinely new chapter for rice pest management. Its real value lies in application that is timely and controlled, in cutting down the labour needed inside the field, and in the promise of spraying with more precision than a knapsack ever could manage. None of that arrives automatically, though it depends on correct calibration, sensible flight settings, decent weather, trained hands on the controls and pesticide use that stays responsible throughout. For the rice farmer weighing whether to invest, the message is straightforward: a drone is a tool, not a shortcut. Line up the machine, the spray technology and the pest-management decision correctly, and UAV spraying earns a real place in efficient, sustainable rice production.

REFERENCES

Ahmad, F., Zhang, S., Qiu, B., Ma, J., Huang, X., Qiu, W., Ahmed, S., Chandio, F. A., & Khaliq, A. (2022). Comparison of Water

Sensitive Paper and Glass Strip Sampling Approaches to Access Spray Deposit by UAV Sprayers. *Agronomy*, *12*(6), 1302–1302.

Andryan, R., Junaedi, A., Purwono, P., Prasetyo, L. B., & Wijayanto, A. (2025). Comparison of pesticide manual spraying with drone application on rice. *IOP Conference Series Earth and Environmental Science*, *1528*(1), 12017–12017.

Bonds, J. A. S., Pai, N., Hovinga, S., Stump, K., Haynie, R. S., Flack, S., & Bui, T.-C. (2024). Spray Drift, Operator Exposure, Crop Residue and Efficacy: Early Indications for Equivalency of Uncrewed Aerial Spray Systems with Conventional Application Techniques. *Journal of the ASABE*, *67*(1), 27–41.

Cao, Y., Yu, F., Xu, T., Du, W., Guo, Z., & Zhang, H. (2021). Effects of plant protection UAV-based spraying on the vertical distribution of droplet deposition on Japonica rice plants in Northeast China. *International Journal of Agricultural and Biological Engineering*, *14*(5), 27–34.

Castaldo, J. H. (2023). Revolutionizing agriculture from the skies: exploring the potential of spraying drones in precision farming. *Cadernos de Ciência & Tecnologia*, *40*, 27284–27284.

Chen, S., Lan, Y., Zhou, Z., Deng, X., & Wang, J. (2021). Research advances of the drift reducing technologies in application of agricultural aviation spraying. *International Journal of Agricultural and Biological Engineering*, *14*(5), 1–10.

Delavarpour, N., Koparan, C., Zhang, Y., Steele, D. D., Betitame, K., Bajwa, S. G., & Sun, X. (2023). A Review of the Current Unmanned Aerial Vehicle Sprayer Applications in Precision Agriculture. *Journal of the ASABE*, *66*(3), 703–721.

Deng, Q., Zhang, Y., Lin, Z., Gao, X., & Weng, Z. (2024). The Impact of Digital Technology Application on Agricultural Low-Carbon Transformation—A Case Study of the Pesticide Reduction Effect of Plant Protection Unmanned Aerial Vehicles (UAVs). *Sustainability*, *16*(24), 10920–10920.

Filho, F. H. I., Heldens, W., Kong, Z., & Lange, E. S. de. (2019). Drones: Innovative Technology for Use in Precision Pest Management. *Journal of Economic Entomology*, *113*(1), 1–25.

Grant, S., Perine, J., Abi-Akar, F., Lane, T., Kent, B., Mohler, C., Scott, C., & Ritter, A. M. (2022). A Wind-Tunnel Assessment of Parameters That May Impact Spray Drift during UAV Pesticide Application. *Drones*, *6*(8), 204–204.

Huang, Z., Wang, C., Wongsuk, S., Qi, P., Liu, L., Qiao, B., Zhong, L., & He, X. (2023). Field evaluation of a six-rotor unmanned agricultural aerial sprayer: effects of application parameters on spray deposition and control efficacy against rice planthopper. *Pest Management Science*, *79*(11), 4664–4678.

Koo, D., Gonçalves, C. G., & Askew, S. D. (2024). Agricultural spray drone deposition, Part 2: operational height and nozzle influence pattern uniformity, drift, and weed control. *Weed Science*, *72*(6), 824–832.

Kuster, C. J., Kohler, M., Hovinga, S., Timmermann, C., Hamacher, G., Buerling, K., Chen, L., Hewitt, N. J., & Anft, T. (2023). Pesticide Exposure of Operators from Drone Application: A Field Study with Comparative Analysis to Handheld Data from Exposure Models. *ACS Agricultural Science & Technology*, *3*(12), 1125–1130.

Martins, R. N., Moraes, H. M. F. e, Freitas, M. A. M. de, Lima, A. da C., & Júnior, M. R. F. (2021). Effect of nozzle type and pressure on spray droplet characteristics. *Idesia*, *39*(1), 101–107.

Nag, P. K., & Nag, A. (2004). Drudgery, Accidents and Injuries in Indian Agriculture. *Industrial Health*, *42*(2), 149–162.

Nazarov, D., Назаров, A., & Kulikova, E. (2023). Drones in agriculture: Analysis of different countries. *BIO Web of Conferences*, *67*, 2029–2029.

Quan, X., Guo, Q., Ma, J., & Doluschitz, R. (2023). The economic effects of unmanned aerial vehicles in pesticide application: evidence from Chinese grain farmers. *Precision Agriculture*, *24*(5), 1965–1981.

Rahman, M., Mohanta, K., Uddin, M. Z., & Oliver, M. M. H. (2025). Development and evaluation of a wheel-powered sprayer machine for marginal farmers. *Tractors and Agricultural Machinery*, *92*(1), 57–67.

Sánchez-Fernández, L., Díaz-García, F., Ruiz, M. P., Sandín-España, P., Alonso-Prados, J. L., Mateo-Miranda, M., Martínez-Guanter, J., García-Montero, E., Márquez, M., & Abril-Muñoz, I. (2025). Dermal Exposure of Operators, Bystanders and Residents Derived from Unmanned Aerial Spraying Systems (UASS) in Vineyard. *Drones*, *9*(5), 345–345.

Sarri, D., Martelloni, L., Rimediotti, M., Lisci, R., Lombardo, S., & Vieri, M. (2019). Testing a multi-rotor unmanned aerial vehicle for spray application in high slope terraced vineyard. *Journal of Agricultural Engineering*, *50*(1), 38–47.

Sassu, A., Psiroukis, V., Bettucci, F., Ghiani, L., Fountas, S., & Gambella, F. (2024). Unmanned aerial system plant protection products spraying performance evaluation on a vineyard. *Precision Agriculture*, *25*(4), 2082–2112.

Seni, A., MISHRA, K. M., & Pal, R. (2022). Comparative efficacies of modules against major insect pests and natural enemies in rice (Oryza sativa). *The Indian Journal of Agricultural Sciences*, *92*(7), 911–914.

Spencer, J., & Dent, D. (1991). Walking speed as a variable in knapsack sprayer operation: Perception of speed and the effect of training. *Tropical Pest Management*, *37*(4), 321–323.

Testa, R., Galati, A., Schifani, G., & Migliore, G. (2025). Cost-effectiveness of conventional and precision agriculture sprayers in Southern Italian vineyards: A break-even point analysis. *Precision Agriculture*, *26*(2).

Vijayakumar, S., Murugaiyan, V., Ilakkiya, S., Kumar, V., Sundaram, R. M., & Kumar, R. M. (2025). Opportunities, challenges, and interventions for agriculture 4.0 adoption. *Discover Food*, *5*(1).

Wang, H., Fu, C., Zhou, S., & Lin, Z. (2026). The effect of rotor airflow from plant protection UAV on pesticide application in rice. *Scientific Reports*.

Wang, J., Lan, Y., Zhang, H., Zhang, Y., Wen, S., Yao, W., & Deng, J. (2018). Drift and deposition of pesticide applied by UAV on pineapple plants under different meteorological conditions. *International Journal of Agricultural and Biological Engineering*, *11*(6), 5–12.

Wong, H. L., & Brown, C. D. (2020). Assessment of occupational exposure to pesticides applied in rice fields in developing countries: a critical review. *International Journal of Environmental Science and Technology*, *18*(2), 499–520.

Wong, H. L., Garthwaite, D., Jais, A. N., Norman, N. N., Shobri, N. D. M., & Brown, C. D. (2023). Occupational Exposure to Pesticides Applied by Rice Growers in Malaysia. In *Research Square*.

Yan, X., Zhou, Y., Liu, X., Yang, D., & Yuan, H. (2021). Minimizing Occupational Exposure to Pesticide and Increasing Control Efficacy of Pests by Unmanned Aerial Vehicle Application on Cowpea. *Applied Sciences*, *11*(20), 9579.

Zeng, H., Liu, W., & ZHANG, J. (2025). Parameter optimisation of triflumezopyrim spraying by plant protection UAV and effectiveness of rice planthoppers control. *ACTA AGRICULTURAE UNIVERSITATIS JIANGXIENSIS*, *47*(4), 971–979.