

Application of Herbicides Using Unmanned Aerial Vehicle (UAV)

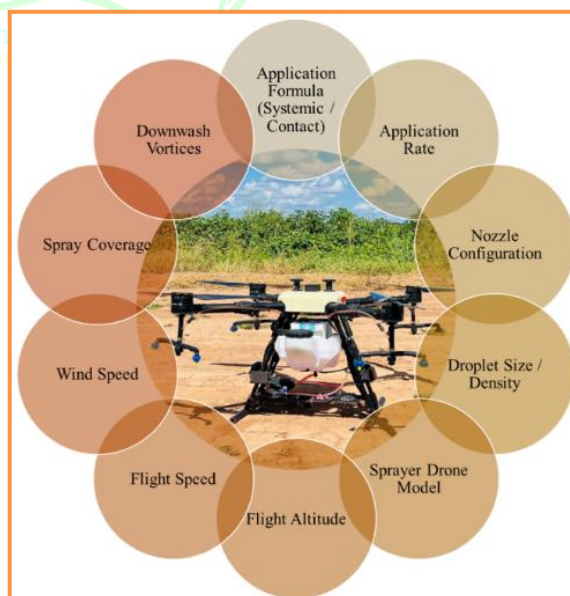
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Weeds are considered one of the most important biotic factors limiting crop productivity. They compete with crops for essential resources such as nutrients, soil moisture, sunlight and space. The extent of competition between crops and weeds varies depending on several factors, including the type of weed species present, the level of weed infestation and the length of time weeds remain in the field. In addition, the competitive ability of the crop and prevailing soil and climatic conditions also influence the intensity of crop–weed competition. As weed pressure increases, crop experience stress, which ultimately results in a decline in grain yield. Thus, the magnitude of yield reduction is closely related to the severity and duration of weed competition in the field. Manual weeding is cumbersome due to labour scarcity and increased cost becoming uneconomical. Herbicides were commonly used for the control of weeds. For application of herbicides knapsack sprayers are commonly used with human labour. Conventionally, knapsack sprayers are the preferred method for chemical application in farm operations. However, it encompasses several constraints such as, shortage of trained labour and high risk of herbicide exposure. It consumes more time and drudgery due to walking in the puddled field with tank load and spraying, which is hindering the weed control efficiency. In the current scenario of high labour costs, and non-availability of labour, advanced technology should be used in agriculture to save time and energy. Drone being a modern technology can be solution for farmers. Agricultural drones provide relief for the modern-day farmers to reduce drudgery and to act timely for crop needs. Unmanned Aerial Vehicle commonly referred as Drone is essentially flying ROBOT remotely controlled through software-controlled flight plans in their embedded system working in conjunction with on board SENSORS and GPS (Global Positioning System). Due to high adaptability of UAV platforms makes them viable alternative for aerial pesticide application (Wang *et al.*, 2018). Unmanned Aerial Vehicles (UAV) were initially designed for military purposes, but the rapid development of efficient technologies such as sensors, Global Positioning Systems (GPS) and civilian-accessible computers has expanded the potential of drones for various applications (Ehsani and Maja 2013; Hogan *et al.*, 2017). Drones are a potential alternative for aerial chemical spraying due to their high adaptability (Wang *et al.*, 2018). Drones can help farmers to save time by assisting in a variety of ways, including soil fertilization,



spraying, irrigation, crop health monitoring, planting and herd tracking. It is possible to work in dampy or sloping environments, reduce work load and application in specific locations is also possible. Drone sprayers also provide Site-Specific Weed Management (SSWM) that includes spraying weed patches only or adjusting herbicide application according to weed density or weed species composition (e.g., herbicide resistant, broad-leaved or grass weeds).

Application of Herbicides in Standing Crops Using Drones

➤ Agricultural Drones and Their Working Principle

Agricultural drones are small aerial machines designed to carry and spray liquid formulations over crop fields. These drones are equipped with components such as a chemical tank, spray nozzles, pumps, batteries, propellers and a GPS-based navigation system. The operator programs the drone to fly over the field following a pre-determined path, allowing it to spray herbicides evenly across the crop area. Most agricultural drones operate at a fixed height above the crop canopy and release the herbicide solution in the form of fine droplets. The rotors of the drone create a downward air flow that helps in better penetration of spray droplets into the crop canopy and improves the effectiveness of herbicide application. With the help of GPS and automated flight systems, drones can cover large areas quickly and ensure uniform distribution of chemicals.

➤ Need for Drone-Based Herbicide Application

Traditional methods of herbicide application usually involve knapsack sprayers, tractor-mounted sprayers, or manual spraying. While these methods are widely used, they have several limitations. Manual spraying is labour-intensive and time-consuming, especially during peak agricultural seasons when labour availability is limited. Tractor-mounted sprayers may cause crop damage due to trampling and are difficult to use in wet or waterlogged fields. In crops such as rice, maize, cotton, and sugarcane, herbicide application becomes more challenging once the crop grows taller. Entering the field for spraying may damage plants and reduce yield. Similarly, in paddy fields with standing water, the movement of labourers and equipment becomes difficult. Under such conditions, drones offer an efficient alternative for herbicide spraying without disturbing the crop.

➤ Advantages of Drone-Based Herbicide Spraying

The use of drones for herbicide application offers several advantages in modern agriculture. One of the major advantages is precision spraying. Drones follow a programmed path and maintain a consistent height above the crop canopy, which ensures uniform distribution of herbicides across the field. This improves weed control efficiency and reduces wastage of chemicals. Another important benefit is the reduction in labour requirements. With increasing migration of rural labour to urban areas, farmers often face difficulties in finding workers for spraying operations. Drone technology helps overcome this problem by enabling a single operator to spray large areas in a short time. Drone spraying also reduces the exposure of farmers to hazardous chemicals. In conventional spraying, operators are directly exposed to herbicide droplets, which can pose health risks. Since drones are remotely operated, the farmer or operator can maintain a safe distance during spraying. Time efficiency is another significant advantage. Agricultural drones can cover several hectares of land in a short period compared to manual spraying. This is particularly useful during critical weed control periods when timely herbicide application is essential.

Additionally, drones require much less water for spraying compared to conventional sprayers. This reduces the volume of spray solution required and improves operational efficiency.

➤ Steps Involved in Drone Herbicide Application

The process of herbicide application using drones involves several steps to ensure effective spraying. The first step is field assessment and mapping. The field area is measured and mapped using GPS or drone software to plan the spraying path. This ensures that the entire field is covered without overlapping or missing any area. The next step is preparation of the herbicide solution. The recommended herbicide and dosage should be mixed properly with water according to label instructions. Correct concentration is important to avoid crop injury and ensure effective weed control. Once the solution is prepared, the drone is calibrated by

setting parameters such as spray height, flight speed, droplet size, and spray width. These parameters depend on the type of crop, stage of growth, and herbicide used. After calibration, the drone begins the spraying operation by flying over the field along the predetermined route. The herbicide is released through spray nozzles as the drone moves across the field. Finally, after spraying is completed, the field should be monitored to assess weed control effectiveness and detect any issues that may require corrective action.

➤ **Crops Suitable for Drone-Based Herbicide Application**

Drone spraying is particularly useful in crops where field access becomes difficult after crop establishment. Some of the important crops where this technology can be effectively used include rice, maize, cotton, wheat, and sugarcane. It can also be applied in pulses, oilseeds, and horticultural crops. In rice fields, drones are especially useful because paddy fields are often flooded and difficult to access using conventional sprayers. Similarly, in tall crops such as maize and sugarcane, drone spraying helps avoid physical damage to plants.

➤ **Precautions for Safe and Effective Use**

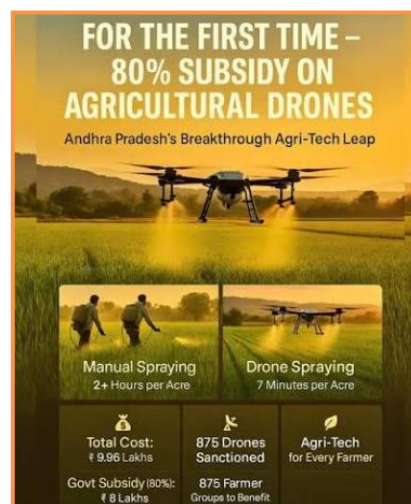
Although drone technology offers many advantages, certain precautions must be followed for safe and effective herbicide application. Farmers should always use herbicides recommended for the crop and follow the recommended dosage. Excessive application may cause crop injury and environmental contamination. Spraying should be avoided during strong winds, as wind may cause drift of herbicide droplets to neighbouring fields. Maintaining the correct flight height above the crop canopy is also important to ensure proper spray coverage. Operators should receive proper training in drone operation, calibration, and maintenance. Additionally, local regulations and safety guidelines related to drone use should be followed.

Challenges and Limitations

Despite its potential benefits, drone-based herbicide application also faces certain challenges. One of the main limitations is the high initial cost of purchasing agricultural drones. Small and marginal farmers may find it difficult to invest in this technology. Another challenge is the need for technical skills and training to operate and maintain drones. Battery capacity also limits the flight duration, requiring periodic recharging or replacement during large-scale operations. Regulatory restrictions related to drone use in certain areas may also affect adoption. However, many governments are gradually relaxing regulations and promoting the use of drones in agriculture.

Government Initiatives and Future Prospects

Many countries, including India, are encouraging the use of agricultural drones to promote precision farming. Government schemes and subsidies are being introduced to support farmers and agricultural entrepreneurs in adopting drone technology. Custom hiring centres and service providers are also emerging, allowing farmers to access drone spraying services without purchasing the equipment themselves. With continuous technological improvements, agricultural drones are expected to become more affordable and efficient in the future. Integration with advanced technologies such as artificial intelligence, remote sensing, and precision agriculture tools may further enhance the effectiveness of drone-based herbicide application.



Conclusion

Drone technology represents a significant advancement in modern agricultural practices. The application of herbicides in standing crops using drones offers a practical solution to many challenges associated with conventional spraying methods. By improving spray precision, reducing labour requirements, minimizing chemical exposure, and saving time, drone-based herbicide application can contribute to better weed management and higher crop productivity.

As technology becomes more accessible and awareness among farmers increases, drones are likely to play an important role in the future of sustainable and efficient agriculture.

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