

Crop Specific Standard Operating Procedure (SOP) For The Application of Pesticides with Drones

(An Extension to the generic SOP for use of drone application with pesticides for crop production and for spraying soil & crop Nutrients in Agriculture, Forestry, Non-cropped areas.)

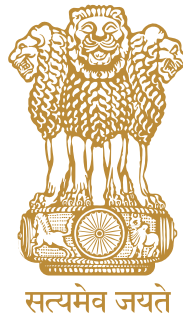


सत्यमेव जयते

Government of India
Ministry of Agriculture and Farmers Welfare
Department of Agriculture and Farmers Welfare
(Mechanization and Technology Division)
Krishi Bhawan, New Delhi

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नरेन्द्र सिंह तोमर
NARENDRA SINGH TOMAR



कृषि एवं किसान कल्याण मंत्री
भारत सरकार
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MINISTER OF AGRICULTURE
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GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI

D.O. No. 250/AM



MESSAGE

The use of Agricultural Drones, as one of the latest and most precise technology, have great potential to transform Indian agriculture. The National drone policy has been notified and the Drone Rules 2021 have made significantly easier for the people and companies in the country to now own and operate drones.

Realizing the plethora of advantages of Agricultural Drone, Ministry of Agriculture and Farmers Welfare, is promoting the Agricultural drones under the **Sub Mission on Agricultural Mechanization** by providing the financial assistance on procurement of drones and organizing the drone demonstrations. The Agricultural drones are capable of spraying of pesticides & soil/crop nutrients, yield and damage assessment, digitization of land record, monitoring crop health, analysis of nutrient levels, soil moisture content and more.

In spraying chemicals manually with knapsack sprayers, the safety & health hazard to the operators was always a major concern besides it was time-consuming and labour-intensive. Application of drones to treat infected plants is much safer and more efficient and enabling farmers to save money by not wasting treatment on plants that don't need it.

The Agriculture Drone is new and bit complex technology in agriculture. For crop spraying with pesticides & soil/crop nutrients, farmers need guidance for its efficient, effective, & safe application. Therefore, this Ministry has already published a generic Standard Operational Procedure (SOPs) for easy understanding on safety, regulatory operational requirements of Using drones with pesticides.

Going a step forward a **Crop Specific SOPs** for drone application in spraying pesticides is now prepared. It has widened the potential use of Kisan Drones with pesticides in 10 different crops, which are being grown under diverse agro-climatic conditions that includes relevant parameters like; temperature, humidity, wind speed, terrain conditions and crop conditions/stages etc.

I congratulate all professionals of the team from Ministry of Agriculture and Farmers Welfare, ICAR institutions, SAUs, drone and pesticide industries who contributed in bringing out this publication with very concise & reliable instructions for effective, efficient and safe operations of drones under different agro-climatic conditions of this country.

(Narendra Singh Tomar)

कैलाश चौधरी
KAILASH CHOUDHARY



कृषि एवं किसान कल्याण
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GOVERNMENT OF INDIA



MESSAGE

As Drones have become an integral part of innovative & precision farming and enable farmers to deal with a wide range of challenges & issues. The numerous benefits associated with use of drone technology have the potential as a game-changer in Agriculture sector. Using a drone, can help farmers, in increasing their farm productivity and profitability. This technology is also environment friendly and suitable for remote and difficult areas, which ensures its success in agriculture. Drones for spraying pesticides are helping automate this process, along with helping humans avoid getting in contact with harmful chemicals. Kisan drones help in increasing the speed of operations, reduce time, and increase safety, all at the same time.

This Ministry has already published generic SOP for the use of Drones with pesticides having guidelines for the farmers for effective, efficient, safe and responsible use of drones with pesticides. However, to make the more precise & effective use of Drones for different crops under the varying agroclimatic conditions across the country, another Crop Specific SOPs have been formulated for the farmers and other stakeholders. By providing the accesses to information of these SOPs, farmers can get benefits for crop yields, time saving, reduce expenses and precision in spraying pesticides using drones.

At the end, I extend my best wishes to M&T & Plant Protection Divisions of the Ministry, expert members from SAUs, ICAR institutions, Drone & pesticides manufacturers, stake holders, to bring out this publication which would be instrumental in promotion of Application of Drones for spraying pesticide.

(Kailash Choudhary)

शोभा करांदलाजे
SHOBHA KARANDLAJE



राज्य मंत्री
कृषि एवं किसान कल्याण
भारत सरकार
Minister of State For
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Government of India



24, February, 2023

MESSAGE

Drones are well-equipped with many features, like sprayers, multi-spectral and photo cameras and can be used in many areas of agriculture sector such as spraying of pesticides & crop nutrients, monitoring crop stress, plant growth, crop yields and damage assessment, analysis of water requirements etc. The use of drones with pesticides enable the farmers to spray the exact amounts of chemicals needed to fight infestations thereby optimizing the overall cost for the farmers.

The earlier Generic SOP published by this Ministry for pesticides & crop nutrients application with Agricultural drones covers important aspects like statutory provisions, flying permissions, area distance restrictions, weight classification, overcrowded areas restriction, drone registration, safety insurance, piloting certification, operation plan, air flight zones, weather conditions, SOPs for pre, post and during operation, emergency handling plan etc.

This latest Crop specific Standard Operational Procedures have been brought out for guidance on technical, operational & safety requirements during spraying of pesticides in 10 crops namely, paddy/ rice, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean, sugarcane and wheat, under the varying external climatic conditions such as temperature, humidity, soils, wind speeds, crop conditions/stage etc.

I congratulate and extend my best wishes to the concerned officers, from this Ministry, scientists and expert members from, SAUs, ICAR, Drone & pesticides manufacturing industries and their association for contributing and sharing their inputs to bring out this publication for farmers and other users of Agricultural drones.

(Shobha Karandlaje)

MANOJ AHUJA
SECRETARY



भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि एवं किसान कल्याण विभाग
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture & Farmers Welfare



MESSAGE

Agricultural drone has great potential in the agriculture sector through its application in creating real-time maps of fields, monitoring crop conditions, plant health and crop yield, evaluation of germination, predicting the productivity, checking the quality of plowing, and maintaining environmental monitoring of agricultural land. Drones are also used for various other tasks, including weed, insect, disease management, spraying pesticides & crop nutrients, spreading micro-granular and fertilizers etc.

To leverage this Drone Technology, the Ministry of Agriculture is providing the financial assistance for procurement of Agriculture Drones and drone demonstrations with pesticides & crop nutrients, under the **Sub Mission on Agricultural Mechanization** Scheme of the Ministry of Agriculture and Farmers Welfare.

Application of Drones for spraying pesticides and other activities require specialized skills and knowledge which an average farmer lacks. Hence, farmer/end-user needs to have the required knowledge & information for the safe & effective application of Kisan Drones in Agriculture.

Keeping this in mind, this Ministry had already published a generic Standard Operational Procedure (SOPs) for use of Drones that will guide the farmers/users/operators/regulators for undertaking safe and effective control of pest & diseases by Drone compatible pesticide application.

However, keeping in view that more precise, efficient and dependable use of drone technology with pesticides in different crops and to accommodate the varying agroclimatic conditions across the country, this crop specific SOPs has been brought out for easier understanding to the farmers.

I congratulate the team led by Dr. Indramani, officers of DA&FW, expert members from ICAR institutions, SAUs, Drone and pesticides industries for their contribution and completing this magnificent work in a very professional way in a limited time.

(Manoj Ahuja)

February 24th, 2023

Dr. Abhilaksh Likhi, IAS
Additional Secretary



भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि एवं किसान कल्याण विभाग
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MESSAGE

Kisan Drone is now the beginning of a new age revolution in agriculture sector which can be used for mapping, soil health & water stress management, land survey, crop health monitoring, crop yield & damage assessment and spraying agricultural pesticides & crop nutrients etc.

Kisan Drones are going to be important for increasing the efficiency of application of crop protection chemicals by reducing manpower requirement, reducing time of application, reducing volume of water, quantity of chemicals and saving drift to environment along with reducing exposure to human-being to hazardous chemicals.

Earlier, this Ministry has released Generic Standard Operating Procedure (SOP) for crop spraying with pesticides and crop nutrients. This SOP includes statutory provisions, flying permissions, operation plan, weight classification, area distance restrictions, overcrowding restrictions, safety insurance, drone registration, piloting certification, air flight zones, and weather conditions and all-important aspects for pre, post, and during the operation, as well as an emergency handling plan.

However, keeping in view that technical and operational requirement for application of Pesticides using Agricultural Drone, varies with different crops & agro-climatic conditions. Therefore, separate crop specific SOPs for more precise, optimum, safe and judicious use of this Drone technology for pesticide application in different crops have been prepared.

I congratulate all scientists, professors, officers, expert members from Ministry of Agriculture, ICAR institutions, SAUs and drone & pesticides industries, for their creditable inputs in bringing out this publication. I am in no doubt that it would be a valuable tool to promote the Kisan Drones for crop spraying with pesticides. These SOPs will help farmers in comprehensive understanding of compliance of standards, statutory & regulatory provisions, safety and operational requirements etc, to ensure safe, effective, efficient and consistent application pesticides with Kisan Drones.

(Dr Abhilaksh Likhi)

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DISCLAIMER: This Standard Operating Procedure (SOP) is extension of the previously published “SOP for use of Drone Application with pesticides for crop production and spraying soil and crop nutrients in agricultural, forestry and non cropped area”. The data produced in this SOP is a research data on small category drone.

Preface

Modern crop production and management for sustainable and profitable agriculture requires an early information system to know about crop health condition. Similarly, the quick response to address the undesirable damages caused by biotic and abiotic stresses is important to minimize the losses. Labour shortage and increased input cost of crop production is another challenge that needs to be addressed immediately. So judicious use of inputs by precision methods of applications is need of the hour. Unmanned aerial vehicles (UAVs), commonly known as “drones” can effectively be used for application of crop inputs (Plant protectants and crop nutrients). Aerial spraying using drones saves huge time and labour requirement and thus, allows large areas to be treated within a very short period. Spraying through drones can be carried out when field conditions prevent movement of man and ground machines. It enables the timeliness of spray treatments without inflicting soil compaction. Drones can be used for timely detection of insects and pests, crop health monitoring, targeted input application, and rapid assessment of crop yield and crop losses.

There are, however, certain disadvantages associated with drone spraying. High wind speed and temperature inversion may limit treatment application whilst trees, waterways, environmental considerations and overhead power lines may also prevent some fields from being treated. Volatility and spray drift are problems associated with drone spraying which can lead to environmental contamination, if spraying is incorrectly executed. Also, unsafe piloting of drones may cause security concerns to the operators and others.

Furthermore, in order to maximize the crop production from the minimum crop inputs under prevailing climatic conditions, need-based, location specific technologies are required. To make drone spraying technology feasible and popular, optimum bioefficacy and no phytotoxicity must be ensured.

In fact, any technology including drone assisted spraying has to be explored for its potential use in different crops and for different agro-climatic zones. Thus, to widen the scope of drone assisted pesticide application for different crops grown under diverse climatic conditions, there is an urgent need to have crop specific SOPs taking into considerations the relevant parameters like temperature, humidity, wind speed, terrain conditions and crop as well as other environmental parameters.

Methodology

The methodology followed for data collection for preparation of crop specific Standard Operating Procedures (SOPs) involved scientific deliberations and information collection through online survey schedules. The committee members along with co-opted members and industry representatives held number of scientific deliberations on the type of experimental data required for preparation of crop specific Standard Operating Procedures (SOPs) for application of drones. Based upon the input from different members, a survey schedule was prepared for collection of information from different ICAR Institutes, SAU's and private industries working on different aspects of drone assisted chemical application, experimental location, environmental conditions, chemical formulations, drone and spraying system specifications, operational conditions, observational parameters, phyto-toxicity, bio-efficacy and other critical observations. Proforma used for collection of Information is available in Annexure-I. The developed survey schedule was sent to different SAUs, ICAR Institutes and private industries for submission of experimental data related to drone assisted chemical application carried out at their respective centres. In order to facilitate online submission of information, a Google form page of survey schedule was also created. The link of the same was shared with different research institutes and stakeholders to submit information online. In total, seventy-seven (77) responses were received from different research institutions covering experimental data on drone assisted pesticide application in different crops. The information received was systematically arranged and classified both crop and pesticide wise. Overall, the information was received for ten major crops viz. rice, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean, sugarcane and wheat.

Based on the available information for the crops, the specific SOPs were developed for application of different pesticides through use of drones. The crop specific SOPs mostly focused on crop canopy volume, crop growth stages, pesticide concentration, dosage, water volume per hectare, drone height above crop canopy, flight speed and spray discharge rate.

Standard Operating Procedure for selected crops

The data was received for ten selected crops i.e. rice, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean sugarcane and wheat. Based on the information collected from different institutions/industries, the crop specific SOPs were developed for application of different pesticides/fungicides through use of drones. The SOPs are mainly based on drone parameters (drone flying speed, height of drone above the crop canopy), sprayer parameters (nozzle and swath characteristics), crop parameters (crop canopy volume, crop growth stages, water volume per hectare, pesticide concentration and dosage, suitable time of spray), weather conditions (temperature, humidity, wind speed) as per location and climatic zone with major emphasis on optimum bioefficacy and no phytotoxicity. The crop specific SOPs developed considering a standard drone with tank capacity of 10 liters and overall drone weight less than 25 kg.. The height of the drone above the crop canopy is related to overall weight of the drone, downwash effect over the crop canopy and sprayer characteristics. The drone has to fly near the crop canopy as much as possible to avoid drift during operation and to safeguard the environment. However, the drone should maintain a vertical clearance above the crop, while flying, so that the thrust created by the former should not lead to lodging of the latter. Therefore, operation at optimum height is important. Similarly, the drone flight speed affects the uniformity of spray and needs to be optimized. The procedure for the selection of the drone speed and nozzle height from the crop canopy is given in chapter 5. As per the data received for different crops and included in this report, no crop damage or phytotoxicity was observed at the tested concentrations of the selected pesticides at different selected doses and their respective combinations when sprayed using drones. The experiments on the above aspects were conducted in Southern Plateau and Hills, Trans – Gangetic Plains Agro-climatic region by selected institutions/industries. The summary of the Standard Operating Procedure for 10 crops is shown in table 1. The crop wise list of pesticide molecules tested for phytotoxicity (crop safety) using drones is available in Table 2.

Table-1: SOPs for ten crops

S.No.	1	2	3	4	5	6	7	8	9	10
	Rice	Cotton	Maize	Groundnut	Pigeon pea	Safflower	Sesame	Soybean	Sugar cane	Wheat
1. Drone flying speed (m/s)										
During spraying	4.5-5.0	4.5-5.0	4.5-5.0	4.5-5.0	4.0-5.0	4.5-5.0	4.5-5.0	3.5-4.5	2.0-3.0	4.5-5.0
During launch, RTL and turning	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5
2. Drone height above crop canopy (m)										
Good crop conditions	1.5-2.5	1.5-2.5	1.5-2.0	1.5-2.0	1.5-2.5	1.5-2.5	1.5-2.5	1.5-2.5	3.0-4.0	3.0-4.0
Varieties/ conditions prone to lodging	2.0-3.0	2.0-2.5	2.0-2.5	2.0-2.5	2.0-2.5	2.0-2.5	2.0-2.5	2.0-2.5	-	-
3. Water volume (l/ha)										
Stage-1 : Early stage	20	20	20	20	20	20	20	20	20	20
Stage-2: Full canopy stage	25	25	25	25	25	25	25	25	25	25
4. Nozzles										
Type (Anti drift)	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan	Flat fan
Droplet Size (µm) for Insecticide	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350
Droplet Size (µm) for Fungicide	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350
Discharge rate (litre/min)	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6	0.3-0.6
Angle (Degree)	60-120	60-120	60-120	60-120	60-120	60-120	60-120	60-120	60-120	60-120
Swath(m)	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
Number	4-6	4-6	4-6	4-6	4-6	4-6	4-6	4-6	4-6	4-6
Pressure (bar)	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3
5. Suitable time schedule for spray										
Summer and rainy season:	6 am-10am	6am-10am	6am-10am	6am-10am	6am-10am	6am-10am	6am-10am	6am-10am	6am-10am	6am-10am
	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm	3pm-6pm
Winter season:	8am-11am	8am-11am	8am-11am	8am-11am	8am-11am	8am-11am	8am-11am	8am-11am	8am-11am	8am-11am
	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm	2pm-6pm
*Strictly avoid spraying during flowering stage	6am-11am	-	6am-11am	-	6am-11am	6am-11am	6am-11am	6am-11am	-	-

6. Weather conditions										
Temperature (°C)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)	< 35 (preferably)
Humidity (%)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)	> 50 (preferably)
Wind speed (m/s)	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3
During rain	Don not spray	Don not spray	Don not spray	Don not spray	Don not spray	Don not spray	Don not spray	Don not spray	Don not spray	Don not spray
If visibility during fog/mist is not good	Do not operate	Do not operate	Do not operate	Do not operate	Do not operate	Do not operate	Do not operate	Do not operate	Do not operate	Do not operate
7.Site Specific										
Plain land: Take care of obstacles present in the field	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes
Sloppy terrain: Use terrain following sensors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes
8. Length of buffer zone (m) to avoid										
non targets crops	5	5	5	5	5	5	5	5	5	5
Water bodies etc.	100	100	100	100	100	100	100	100	100	100

Table-2: The crop wise list of pesticide molecules tested for phytotoxicity (crop safety) using drones;

Crop	Insecticides, Fungicides alone & in combinations
Rice	Chlorantraniliprole 18.5SC, Tebuconazole 50 + Trifloxystrobin 25 (75WG), Propiconazole 25EC, Azoxystrobin 18.2 + Difenoconazole 11.4SC, Picoxystrobin 7 + Propiconazole 12 SC, Chlorantraniliprole 18.5SC and (Tebuconazole 50 + Trifloxystrobin 25 - 75 WG), Chlorantraniliprole 18.5SC and (Picoxystrobin 7 + Propiconazole 12 SC), Chlorantraniliprole 18.5SC and (Flupyroxad 62.5 + Epoxiconazole 62.5EC), Chlorantraniliprole 18.5SC and (Azoxystrobin 18.2 + Difenoconazole 11.4SC), (Acephate 50 + Imidacloprid 1.8 SP) and (Mancozeb 50 + Carbendazim 25 WP), Triflumezopyrim 10SC, Pymetrozine 50WG, Dinotefuran 50SG, Cartap hydrochloride 50SP and Mancozeb 50 + Carbendazim 25 WP.
Cotton	Flonicamid 50 WG, Spinetoram 11.7SC, Monocrotophos 36SL, Profenophos 50EC, Acephate 75SP, Diafenthiuron 50WP, Fipronil 5SC, Imidacloprid 17.8SL, Acetamiprid 20 SP, Carbendazim 50WP, Propiconazole 25EC, Kresoxim methyl 44.3SC, Chlopyrifos 50 + Cypermethrin 5EC, Tebuconazole 50 + Trifloxystrobin 25 Metiram 55 + Pyraclostrobin 5, Azoxystrobin 18.2 + Difenoconazole 11.4SC
Redgram (Pigeonpea)	Monocrotophos 36SL, Quinalphos 25EC, Chlorantraniliprole 18.5SC, Flubendiamide 39.35SC, Indoxacarb 14.50SC, Emamectin Benzoate 5SG, Spinosad 45SC, Novaluron 5.25 + Indoxacarb 4.50SC, and Chlorantraniliprole 9.30 + Lambda-cyhalothrin 4.6 ZC
Groundnut	Tebuconazole 25.9EC, Chlorantraniliprole 18.5SC and Tebuconazole 25.9EC
Soybean	Chlorantraniliprole 18.5SC, Chlorantraniliprole 18.5SC
Wheat	Pyraclostrobin 133 g/l + Epoxiconazole 50 g/l SE (Opera 18.3 SE) @ 750 ml Pyraclostrobin 133 g/l + Epoxivpnazole 50 g/l SE (Opera 183 SE) @ 1500 ml/ha

*For the maize, Sesame and safflower crops, no phytotoxicity was observed. However, the chemicals used were not included in the CIBRC's recommended pesticide.

*For sugarcane crop the SOPs are only for drone operating and spraying system parameters (as phytotoxicity and bioefficacy data was not available).

General Guidelines for pest management in crops;

- Do not spray if there is forecast of heavy rains in next 1-2 days.
- Avoid broad-spectrum insecticides when a narrow-spectrum or more specific insecticide will work. Preferably use green labeled insecticides.
- Avoid repeated usage of the same insecticide, insecticides of the same chemical class, or insecticides in different classes with similar mode of action and rotate/alternate insecticide classes and having different modes of action.
- Insecticides should be used only as a last resort when all other non-chemical management options are exhausted and P: D ratio is above 2: 1.
- Apply bio-pesticides/chemical insecticides judiciously after observing unfavorable P: D ratio and when the pests are at most vulnerable life stage. Use application rates and intervals as per label claim.
- Always use protective clothing, face mask and gloves during preparation and application of pesticides.
- Enter the field only after 48 hours of spraying pesticides. Minimum interval between application of chemical insecticide and harvest of maize corn should be 30 days.

Ready-Reckoner to determine drone flying and spraying parameters

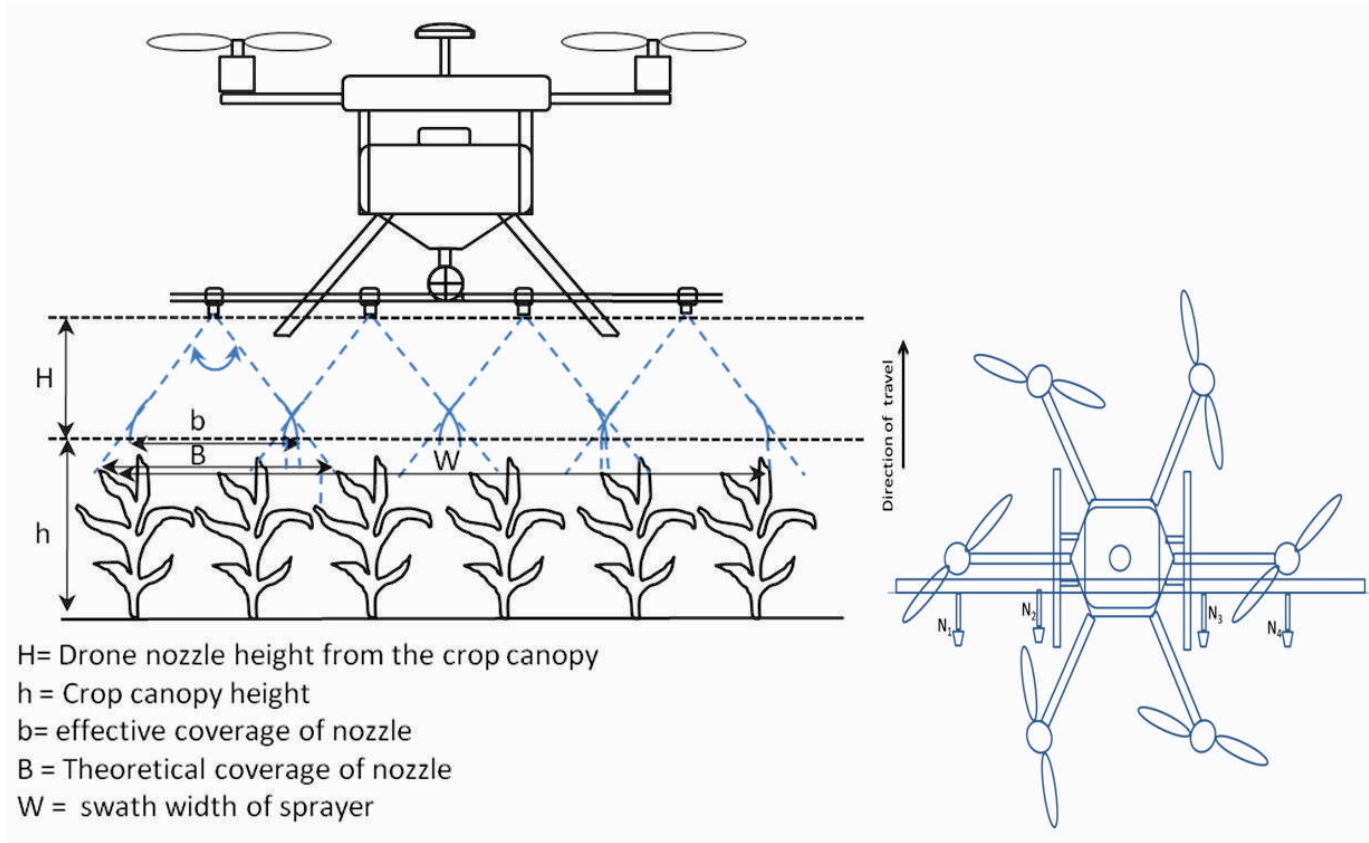
Following table may be used as ready reckoner to set the drone flying speed for uniform spray application based on swath, nozzle discharge and water volume per ha.

- Evaluate the discharge rate of nozzles (liter/min),
- Count the no. of nozzles
- Determine the swath (cm) of the Drone at known height of spraying.
- Decide on volume (litre) of spray solution (water plus pesticide formulation) to be sprayed per ha.
- Work out the speed (m/s) of the drone to be maintained during spraying.
- Calculate the time required to spray one acre

Swath (centimeter)		300	300	300	400	400	400	500	500	500	600	600	600
Water Volume (Liter/ha)		16	20	24	16	20	24	16	20	24	16	20	24
Liter/ min	Nozz- les												
0.300	4	4.17	3.34	2.78	3.13	2.50	2.09	2.50	2.00	1.67	2.09	1.67	1.39
0.350	4	4.87	3.89	3.24	3.65	2.92	2.43	2.92	2.34	1.95	2.43	1.95	1.62
0.400	4	5.56	4.45	3.71	4.17	3.34	2.78	3.34	2.67	2.22	2.78	2.22	1.85
0.450	4	-	5.00	4.17	4.69	3.75	3.13	3.75	3.00	2.50	3.13	2.50	2.09
0.500	4	-	5.56	4.63	5.21	4.17	3.48	4.17	3.34	2.78	3.48	2.78	2.32
0.550	4	-	-	5.10	-	4.59	3.82	4.59	3.67	3.06	3.82	3.06	2.55
0.600	4	-	-	5.56	-	5.00	4.17	5.00	4.00	3.34	4.17	3.34	2.78
0.3	6	-	5.00	4.17	4.69	3.75	3.13	3.75	3.00	2.50	3.13	2.50	2.09
0.35	6	-	-	4.87	5.47	4.38	3.65	4.38	3.50	2.92	3.65	2.92	2.43
0.4	6	-	-	5.56	-	5.00	4.17	5.00	4.00	3.34	4.17	3.34	2.78
0.45	6	-	-	-	-	-	4.69	-	4.50	3.75	4.69	3.75	3.13
0.5	6	-	-	-	-	-	5.21	-	5.00	4.17	5.21	4.17	3.48
0.55	6	-	-	-	-	-	-	-	5.50	4.59	5.73	4.59	3.82
0.6	6	-	-	-	-	-	-	-	-	5.00	-	5.00	4.17

Swath at different operational heights and spray angles of nozzles

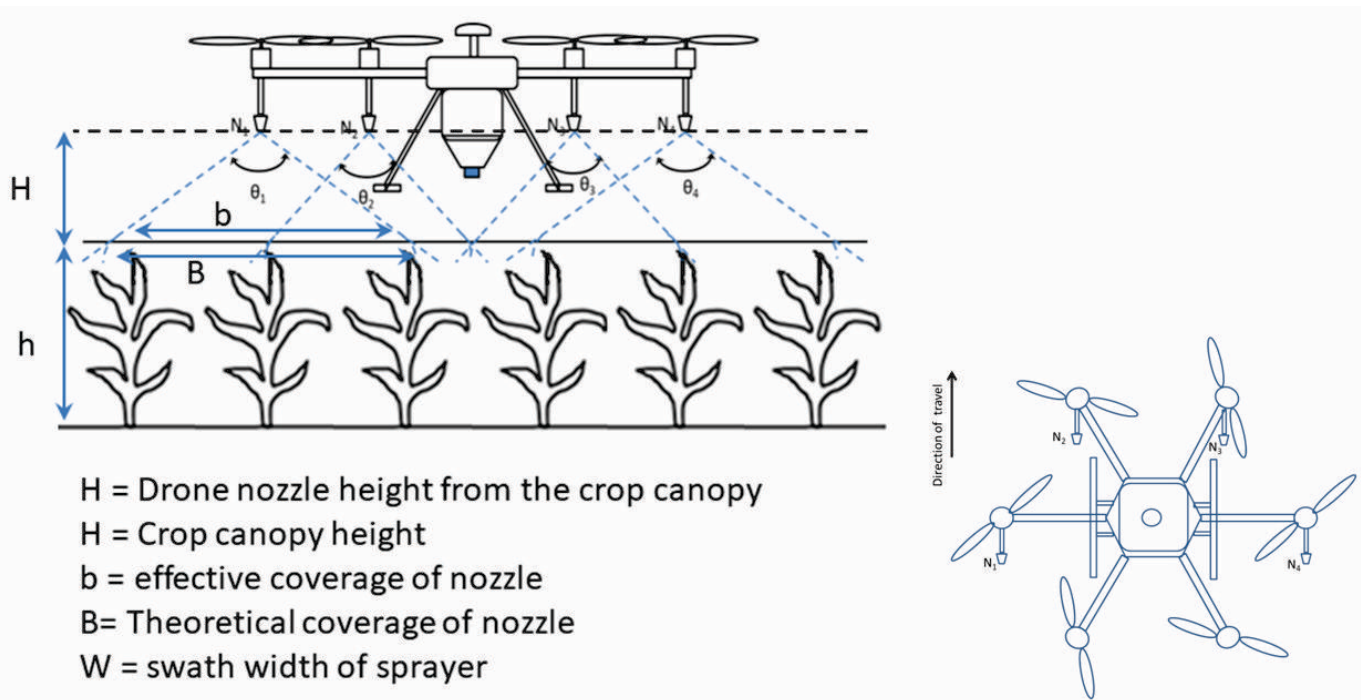
(a) Drone with boom sprayer



H = Drone nozzle height from the crop canopy
 h = Crop canopy height
 b = effective coverage of nozzle
 B = Theoretical coverage of nozzle
 W = swath width of sprayer

	Theoretical coverage (b, meter) at different spray height (H, meter)						
Spray Angle (Degree)	1.50	1.60	1.70	1.80	1.90	2.00	2.50
45	1.24	1.33	1.41	1.49	1.57	1.66	2.07
60	1.73	1.85	1.96	2.08	2.19	2.31	2.88
80	2.52	2.68	2.85	3.02	3.18	3.35	4.20
90	3.00	3.20	3.40	3.60	3.80	4.00	5.00
110	4.28	4.57	4.85	5.14	5.42	5.71	7.14
120	5.20	5.54	5.89	6.24	6.58	6.93	8.66

(b) Drone with nozzles below the propeller

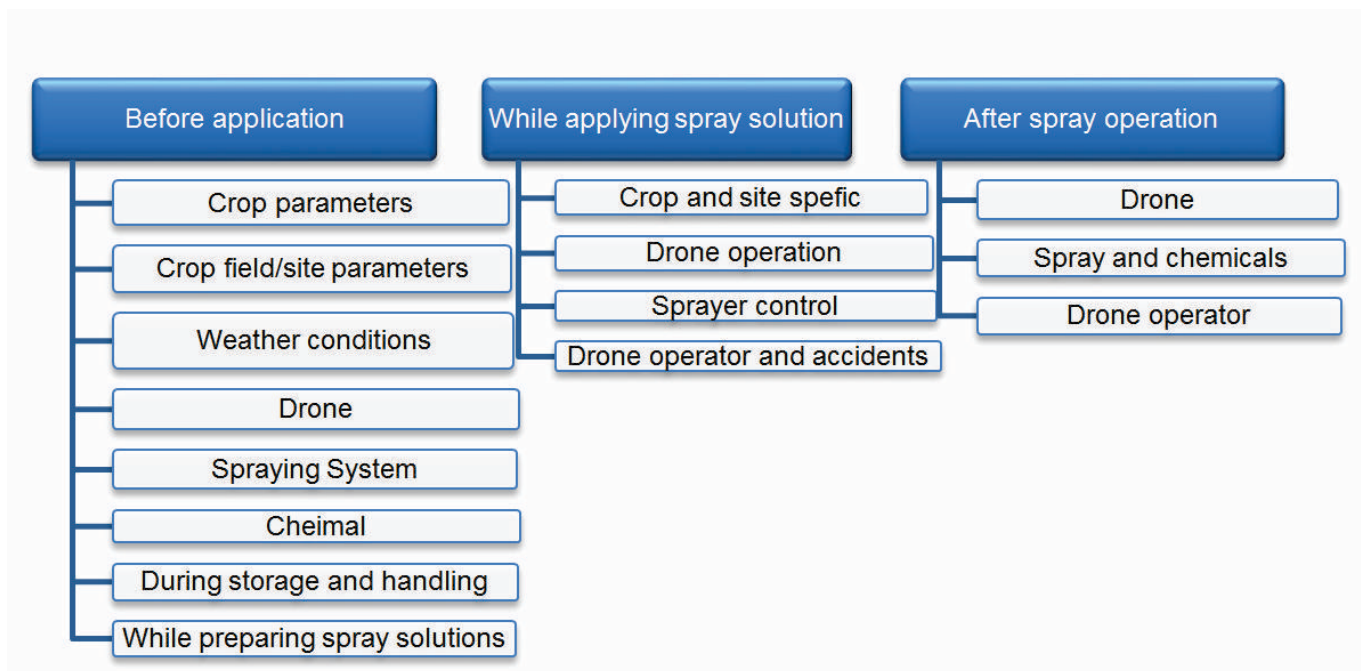


Nozzle	Spray Angle (Degree)
N1	60-120
N2	60-90
N3	60-90
N4	60-120

Operational and safety requirements to ensure the safe, efficient and effective use of the inputs and the technology

The following operational and safety measures need to be followed to ensure safe, efficient and effective use of the inputs and the drone technology

Do's and Don'ts for pesticide application using drone



Do's	Don'ts
Before Application of pesticide using drone	
<p>Crop Parameters:</p> <ul style="list-style-type: none"> ✓ The crop stage, height and canopy development should be taken into consideration before spraying using drone. ✓ The drone can be operated as per the crop condition for spot, band or elevated targeted spraying. For spot spraying the area should be marked first using appropriate marker. ✓ The drone spraying is most ideas for mono cropping pattern. 	<ul style="list-style-type: none"> ✗ Avoid pesticide spray during pollination stage. ✗ Avoid using drone if crop is prone to lodging. ✗ Avoid chemical spray using drone if rain is forecasted.
<p>Crop Field: Site parameters</p> <ul style="list-style-type: none"> ✓ Check field comes under green, yellow or red zone. If field comes under yellow zone take proper permissions from DGCA and local police. ✓ Note down the Latitude and Longitude of the field for the record. 	<ul style="list-style-type: none"> ✗ Do not plan for pesticide spray using drone if field comes under red zone.

<ul style="list-style-type: none"> ✓ Check GPS connectivity and stability status. ✓ Check shape of the field whether drone can be used or not. ✓ Check terrain conditions (Slope, Plain or hills etc.). ✓ Check obstacles in the field like Trees, poles, HT line, Hill, power stations, solar systems, pumping station, fencing, agriculture machinery etc. ✓ Check Line of sight. ✓ Check the suitable Take off & Landing area 	<ul style="list-style-type: none"> ✗ Do not plan for spraying using drone nearby fodder crop, grazing field, water bodies like pond, river, canal etc., village, no crop field, roads, poultry house, barn yard, schools, etc. and maintain a minimum distance of 100m from these bodies. ✗ Do not plan for a large field spraying (beyond visual line of sight) using drone to avoid risk of signal loss between remote control and the drone.
<p>Weather/Environmental conditions:</p> <ul style="list-style-type: none"> ✓ Note down the date and time for spraying in log book. ✓ Check the temperature and plan for spray if temperature is preferably less than 35 °C preferably. ✓ Check the humidity and plan for spray if humidity is more than 50 %. ✓ Check the wind speed and plan for spray if the wind speed is less than 3 m/s. ✓ Check the wind direction and according fix the starting home point of the drone for flying. ✓ Consider the weather forecast and take the decision accordingly for drone flying. Cloudy conditions would deter GPS connectivity 	<ul style="list-style-type: none"> ✗ Do not plan for pesticide spray using drone if temperature is more than 35°C. ✗ Do not plan for pesticide spray using drone if humidity is less than 50%. ✗ Do not plan for pesticide spray using drone if wind speed is more than 3m/s. ✗ Do not plan for chemical spray using drone if the rain is expected within 6 hours.
<p>Drone:</p> <ul style="list-style-type: none"> ✓ Always have motor, propeller, ESC and battery in spare. ✓ Note down the drone type and payload capacity. ✓ Always carry a proper tool kit according to Drone flying for Spraying. ✓ The drone should be capable of flying in both Manual and Auto mode interchangeably. ✓ Calibrate the drone and ensure good stability during operation. ✓ Check chemical feeder pipes to the nozzle for airlocks ✓ Ensure the nozzles are free from clogging and scaling 	<ul style="list-style-type: none"> ✗ Do not fly drone if batteries are not in good condition and not properly charged or bulged. ✗ Do not fly drone if propellers are broken or cracked. ✗ Do not fly drone if motor is heating too much ✗ Don't fly a Nano drone above 50 feet from the ground level. ✗ Don't fly a micro drone above 200 feet from the ground level. ✗ Don't fly drones more than 400 feet above the ground level. ✗ Don't fly drone near other aircraft (manned or unmanned).

<ul style="list-style-type: none"> ✓ Ensure uniformity in discharge from each nozzle ✓ Check the GPS accuracy and decide the overlap percentage. ✓ Calibrate the RTK GPS based station if auto mode flying is planned. ✓ Check and calibrate the drone sensors like Lidar, Baro meter Radar etc. ✓ Optimize the drone speed range. ✓ Check remote control range and batteries status. ✓ Check the Battery capacity and status and note down the battery age, number of battery etc. ✓ Check the drone components for proper fitting. ✓ Check the drone propellers are in good condition. ✓ Check the drone motors are in good condition. ✓ Check the motor temperature. ✓ Check the drone propellers are in proper orientation . ✓ Obtain Unique Identification Number (UIN) from DGCA for operating in controlled airspace (where the ATC services are active) and affix it on your drone. ✓ Obtain Unique Identification Number (UIN) from DGCA for drone before flying ✓ Obtain RPTO License for flying the drone of respective category (i.e. for small drone or medium drone). ✓ Obtain Unmanned Aircraft Operator Permit (UAOP), if applicable from DGCA for commercial operations and keep it handy. ✓ Fly only during daylight (after sunrise to before sunset). ✓ Fly in good weather: Good weather lets you not only to fly your drone better but also to keep track of it when it is airborne. ✓ Fly within visual line of sight (VLOS): Always be within visual range of your drone. ✓ Be aware of airspace restrictions/ no drone zones and respect privacy of people. 	<ul style="list-style-type: none"> ✗ Don't fly drone near airports and heliports. ✗ Don't fly drone over groups of people, public events, or stadiums full of people without prior permission. ✗ Don't fly drone over government facilities/ military bases or over/ near any no-drone zones. ✗ Don't fly drone over private property without permission. ✗ Don't fly drone in controlled airspace near airports without filing of flight plan or AAI/ ADC permission (at least 24 hours before actual operation). ✗ Don't drop or carry hazardous material. ✗ Don't fly drone under the influence of drugs or alcohol. ✗ Don't fly drone from a moving vehicle, ship or aircraft.
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<ul style="list-style-type: none"> ✓ Intimate concerned authorities (like DGCA, local police etc.) of any incidents/ accidents within the prescribed tile limit 	
<p>Spraying system</p> <ul style="list-style-type: none"> ✓ Check the tank capacity and its cleanliness ✓ Note down the pump flow rate capacity and set the pressure as per recommendation or as mentioned in operating manual. ✓ Note down the number of nozzles and ensure that the nozzles are not blocked. ✓ Check the nozzles spacing and set as per the manufacturer manual. ✓ Note down the overall boom size of the sprayer. ✓ Check the nozzle discharge rate. ✓ Check the hose pipe and the connector for leakage. ✓ Check the leakage in the water tank and pipe line. ✓ Check the solenoid valve functioning and its control through remote control. ✓ Ensure that the tank is properly cleaned before filling the new chemical. ✓ Select right type and size of nozzles. ✓ Use separate sprayer for insecticides and weedicides. ✓ The droplet size for pesticides should in the range of 250 to 350 microns. 	<ul style="list-style-type: none"> ✗ Do not fly drone if the tank, nozzle, hose pipe are loose. ✗ Do not fill the chemical in the tank more than the recommended level. ✗ Do not fly drone if there is leakage in tank, hose pipe or connector. ✗ Do not fly drone if solenoid valve is not working properly. ✗ Do not fly drone if cap of the tank is missing. ✗ Do not fly drone if drone is unstable. ✗ Do not use leaky or defective equipment. ✗ Do not use defective/wornout and non-recommended nozzles. ✗ Do not blow/clean clogged nozzles with mouth. Instead use tooth brush tied with sprayer. ✗ Never use same sprayer for both weedicides and insecticides.
<p>Chemical:</p> <ul style="list-style-type: none"> ✓ Purchase pesticides/biopesticides only from registered pesticide dealers having valid License. ✓ Purchase only just required quantity of pesticides for single operation in a specified area. ✓ See approved labels on the containers/packets of pesticides. ✓ See Batch No., Registration Number, Date of Manufacture/ Expiry on the labels. ✓ Purchase pesticides well packed in containers. 	<ul style="list-style-type: none"> ✗ Do not purchase pesticides from unregistered dealers or from un-licensed person. ✗ Do not purchase pesticide in bulk and store for whole season. ✗ Do not purchase pesticides without approved label on the containers. ✗ Never purchase expired pesticides. ✗ Do not purchase pesticides whose containers are leaking/loose/unsealed.

<p>During Storage:</p> <ul style="list-style-type: none"> ✓ Store the pesticides away from home premises ✓ Keep pesticides in original containers. ✓ Pesticides/weedicides must be stored separately. ✓ Where pesticides have been stored, area should be marked with warning signs. ✓ Pesticides should be stored away from the reach of the children and live stocks. ✓ Storage place should be well protected from direct sunlight and rain. ✓ Ensure Crop protection chemicals are stored in lock and key. 	<ul style="list-style-type: none"> ✗ Never store pesticide in home premises. ✗ Never transfer pesticides from original to another container. ✗ Do not store insecticides with weedicides. ✗ Do not allow children to enter the storage place. ✗ Pesticides should not be exposed to sunlight or rain water.
<p>While handling:</p> <p>Keep pesticides separate during transportation</p> <ul style="list-style-type: none"> ✓ Bulk pesticides should be carried carefully to the site of application. 	<ul style="list-style-type: none"> ✗ Never carry/transport pesticides along with food/fodder/other eatables. ✗ Never carry bulk pesticides on head, shoulder or on the back.
<p>While preparing spray solution:</p> <ul style="list-style-type: none"> ✓ Always use clean water. ✓ Do not allow the pesticide/its solution to fall on any body parts. Never avoid reading instructions on container's label for use. ✓ Use protective clothings viz., nitrile hand gloves, face masks, cap, apron, full trouser, etc. to cover whole body. ✓ Always protect your nose, eyes, ears, hands, etc. from spill of spray solution. ✓ Read instructions on pesticide container label carefully before use. ✓ Prepare the solution as per requirement. ✓ Avoid spilling of pesticides solutions while filling the spray tank. ✓ Always use recommended dosage of pesticide. ✓ No activities should be carried out which may affect your health. 	<ul style="list-style-type: none"> ✗ Do not use muddy or stagnant water. Never prepare spray solution without wearing protective clothing. ✗ Never use left out spray solution after 24 hours of its preparation. ✗ Do not mix granules with water. ✗ Do not smell the spray tank. ✗ Do not use overdose which may affect plant health and environment. ✗ Do not eat, drink, smoke or chew during whole operation of pesticides spraying.

While applying spray solutions	
Crop and site specific <ul style="list-style-type: none"> ✓ Mark the boundaries of the crop field using flag or Geotag the boundaries. ✓ Check if any other drone operator is flying the drone nearby fields. ✓ Animals should not be allowed to enter into the field during spray operation and upto 48 hours after spray. 	<ul style="list-style-type: none"> ✗ Do not fly drone without marking boundaries of the crop field. ✗ Do not fly drone very close to the crop canopy. It may cause crop lodging.
Drone operation <ul style="list-style-type: none"> ✓ Keep an eye on drone stability during operation. ✓ Keep drone within the visible range. ✓ Take care of obstacles in the crop field. ✓ Take care of overlap percentage of swath. ✓ Take care drone flies within the periphery of crop field. ✓ Drone should have emergency landing option (fail safe mode) when battery discharges ✓ Keep spare charged batteries for emergency. 	<ul style="list-style-type: none"> ✗ Drone operator should not hand over the control of drone to other unskilled person during operation ✗ Do not fly the drone very close to obstacle points. ✗ Do not fly drone out of the visible range. ✗ Do not fly drone if it is unstable. ✗ Do not keep overlap percentage more than 80 percentage or less than 60 percentage. ✗ Do not spray if the nozzles are blocked or leaking. ✗ Do not allow drone to enter adjacent crop fields.
Sprayer control <ul style="list-style-type: none"> ✓ Apply only recommended dose and dilution. ✓ Spray operation should be conducted on cool and calm and sunny day. ✓ Use recommended spraying combination for each mission ✓ Spray operation should be conducted in the windward direction. ✓ After spray operation, sprayer assembly and other equipment used during the operation should be washed thoroughly with clean water using detergent/soap. 	<ul style="list-style-type: none"> ✗ Never apply over-dose and higher concentrations than recommended. ✗ Do not spray on hot sunny day or under strong windy conditions. ✗ Do not spray just before rains and immediately after the rains. ✗ Do not spray against the wind direction. ✗ Containers and buckets used for mixing pesticides should never be used for domestic purpose even after thorough washing. ✗ Never enter in the treated field immediately after spray without wearing protective clothing
Drone operator and accidents <ul style="list-style-type: none"> ✓ Remote control should be in hand of the operator even if the drone is in auto mode. ✓ Drone operator should cover his eyes with goggles to avoid chemical exposure. 	<ul style="list-style-type: none"> ✗ Drone operator should not remove the PPEs during spraying operation ✗ Drone operator should not remove safety goggles during operation.

<ul style="list-style-type: none"> ✓ Drone operator should inform to local police if drone crashed accidentally and it should recoded in log book with proper reason of accidents. Take also the photographs of the accidents. ✓ Operator has to apply for insurance claim as soon as possible. 	<ul style="list-style-type: none"> ✗ Drone operator should not stand in the direction of the wind to avoid chemical exposure due to drift. ✗ Drone operator should not allow other person to stay very near the drone take-off and landing point.
After Spray Operation:	
<p>General</p> <ul style="list-style-type: none"> ✓ Avoid the entry of animals/workers in the field immediately after spray. 	<ul style="list-style-type: none"> ✗ Do not irrigate the field just after spraying of chemicals ✗ Do not harvest the crop immediately after spraying for fodder. ✗ Do not spray fertilizer just after pesticide spray
<p>Drone</p> <ul style="list-style-type: none"> ✓ Take out the battery from the drone and put it for charging immediately. ✓ Check the motor temperature and propellers. ✓ Clean the chemical exposed surfaces of the drone. ✓ All the accessories of drone should be kept in transportation box/bag. 	<ul style="list-style-type: none"> ✗ Do not expose the battery terminal point to avoid short circuiting. ✗ Do not forget the drone and its accessories in the field after spraying
<p>Sprayer and chemicals</p> <ul style="list-style-type: none"> ✓ The used/empty containers should be triple rinsed, dried and punctured and handed over to disposal agency ✓ Left over spray solutions should be disposed off at safer place viz. barren isolated area. 	<ul style="list-style-type: none"> ✗ Empty containers of pesticides should not be re-used for storing other articles. ✗ Left over spray solution should not be drained in or near ponds or water bodies etc.
<p>Drone Operator</p> <ul style="list-style-type: none"> ✓ Clean the PPE after use ✓ Wash hands and face with clean water and soap before eating/smoking. ✓ On observing poisoning symptoms provide the first aid and show the patient to doctor. Also show the empty container to doctor. 	<ul style="list-style-type: none"> ✗ Never eat/smoke before washing clothes and taking bath. ✗ Do not take the risk by not showing the poisoning symptoms to doctor as it may endanger the life of the patient

Proforma used for collection of Information

The proforma for providing the information required for developing the crop specific Standard Operating Procedures (SOPs) for application of Drones with Pesticide and Crop Nutrient Spraying

Notes:

1. This proforma has been developed by a committee constituted for the preparation of the draft for the crop specific Standard Operating Procedure (SOP) for application of Drones - with Pesticide and Crop Nutrient Spraying vide Ministry Order No. F 13-10/2022 M&T (I&P) dated 26th July 2022
2. The proforma consists of the exhaustive list of the parameters required for developing the SOPs.
3. In case of the observations have already been taken, provide the information on parameters (as maximum as possible)
4. In case of the planned drone spraying operations, plan the operations in such a way that the maximum parameters listed in this proforma are recorded.
5. This proforma is for only one spraying operation for a specified crop. In case of more than one spraying during crop growth period (say for different crop growth stages or incidences of pest and disease as observed), use this proforma separately for each operation (if the same drone/spraying system is used for different operations during crop growth stage, details in Tables I, III and IV can be copied for these operations)

Name of the Organization (SAUs, KVKs, ICAR Institutes, FPOsetc) /Individual (farmer, drone service provider etc):

Date of drone spraying:

Table I. Location details

Sr. No.	Parameters	Details
1	Village/town, Tehsil, District, State	
2	Latitude and Longitude	
3	Altitude (m)	
4	Surrounding (sea shore/ flat lands/ forest/ hills)	

Table II. Crop details

Sr. No.	Parameters	Details
1	Crop name	
2	Variety/Hybrid	
3	Type (rainfed/irrigated)	
4	Spacing (row (m) x plant (m))/ Plant population (No/ha)	
5	Date of sowing	
6	Stage of crop (as on date of spraying)	
7	Shaded area (% , if measured OR fully, partly, sparsely based on eye observations) (as on date of spraying)	

Table III. Drone details (as per specifications)

Sr. No.	Parameters	Details
1	Classification (Small/Medium/Large)	
2	Category (Multi-rotor/Hybrid) and No. of rotors	
3	Maximum take-off weight (kg)	
4	Power source (battery/fuel) In case of battery, provide capacity in mAh In case fuel, provide type	
5	Other standard specifications of the drone model used for spraying from Manufacturers (control range, endurance, flight time, controller, fail safe features, etc.) (Provide these specifications here or on separate sheet)	
6	Photographs of the drone model used for spraying (provide here or attach separately)	

Table IV. Spraying system details

Sr. No.	Parameters	Details
1	Tank capacity (lit)	
2	Nozzle mounting (on boom/below propeller)	
3	Length of boom (for boom mounted) (m)	
4	No. of nozzles	
5	Type of nozzle	
6	Cone Angle	
7	Drop let size (μm)	
8	Discharge/Flow rate through nozzle (lit/min)	
9	Operating Pressure (Kg/cm ²)	

V. Formulations sprayed (use appropriate table)**Table V (A). Pesticides (chemical/bio-pesticides)**

Sr. No.	Parameters	Details
1	Target disease/pest	
2	Type of formulation	
3	Name of pesticide	
4	Concentration (g ai/lit or % or ml/ for chemical and ml/Lit for bio-formulations)	
5	Dosage (g/ha or ml/ha)	
6	Water volume (lit/ha)	

Table V (B). Crop nutrients (chemical nutrients/bio-fertilizers)

Sr. No.	Parameters	Details
1	Target deficiency	
2	Type of formulation	
3	Name of crop nutrient	
4	Type of nutrient (nano/micro/macro)	
5	Concentration (g ai/lit or % or ml/ for chemical and ml/Lit for bio-formulations)	
6	Dosage (g/ha or ml/ha)	
7	Water volume (lit/ha)	

VI. Observations

Table VI(A) Environment

Sr. No.	Parameters	Details
1	Temperature (oC)	
2	Relative humidity (%)	
3	Wind speed (km/hr) and direction	

Table VI(B) Drone operating parameters

Sr. No.	Parameters	Details												
1	Flight modes (Manual/Autonomous/A-B mode)													
2	Flying speed (m/s)													
3	Height above canopy (m)													
4	Swath (m)													
5	Overlap (%)													
6	Spray width (m)													
7	Spray flow (lit/min)													
8	Flight direction (Windward side/Leeward side)													
9	Time of spray (start and end)													
10	Total area covered (ha)													
11	Total flight time (spraying time i.e. between drone takeoff to drone landing) required to cover the area, min													
12	In case of multiple flights, provide area covered and flight time for each flight	<table border="1"> <thead> <tr> <th>Flight No.</th> <th>Area (ha)</th> <th>Time (min)</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Flight No.	Area (ha)	Time (min)									
Flight No.	Area (ha)	Time (min)												

Table VI (C) Drone operating parameters

Sr. No.	Parameters	Details
1	Field capacity- Theoretical (ha/hr)	
2	Field capacity- Actual (ha/hr)	
3	Spray Parameters (based on observations with water sensitive papers). Provide averages if recorded as top, middle and lower canopy and on windward, crop and leeward sides and details to be provided in separate tables	
	(a) Volume Median Diameter-VMD (μm)	
	(b) Number Median Diameter-NMD (μm)	
	(c) Droplet density (No./cm ²)	
	(d) Spray uniformity (%)	
4	Control efficiency (%)	
5	Phyto-toxicity observations/effects	
6	Efficacy	
7	Other observations	

VII. Other related information

Committee MEMBERS;

1. Dr. Indra Mani, Vice Chancellor, VNMKV, Parbhani, Maharashtra [Chairman]
2. Er. C. R. Lohi, Deputy Commissioner (M&T), Krishi Bhawan, New Delhi [Member Secretary]
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