No F 13-15/2020-M&T (I&P)
Government of India
Ministry of Agriculture and Farmers Welfare
Department of Agriculture and Farmers Welfare
(Mechanization & Technology Division)
492, Krishi Bhawan, New Delhi
Dated 25th of November, 2022

Subject: Inviting comments from the Stake holders on Draft cropwise Standard Operational Procedure (SOP) for application of the pesticides by using kisan drones-reg.

A copy of the draft crop wise Standard Operational Procedure (SOP) for the application of the pesticides by using kisan drones is being attached herewith for Inviting comments from the respective Stake holders.

The comments may be forwarded through e mail on email IDs cr.lohi@nic.in & pradeep.chopra@nic.in on or before **9th of December 2022** with proper justification.

Encl: Draft SOP

(C.R.Lohi)
Deputy Commissioner (M&T)
01123389019

DRAFT REPORT

Crop Specific SOPs for Application of Pesticides with Drones

Submitted to

(Mechanization and Technology Division)

Department of Agriculture and Farmers Welfare

Ministry of Agriculture & Farmers Welfare

Government of India

Crop Specific SOPs for Application of Pesticides with Drones

Contents

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 protection and crop nutrients). Aerial spraying using drones saves huge time and labour requirement and thus allows large areas to be treated in very short times. 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 of 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 technology are required. To make drone spraying popular, Optimum bioefficacy and no phytotoxicity must be ensured.

In fact any technology including drone assisted spraying has to be explored for 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 urgent need to have crop specific SOPs taking into considerations the relevant parameters like temperature, humidity, wind speed, terrain and crop as well as other environmental parameters.

In view of the above, a committee was constituted by Department of Agriculture, & Farmers Welfare (M& T Division), Ministry of Agriculture & Farmers Welfare, Government of India vide letter No. F13-10/2022-M&T(I&P) dated 26/07/2022) to prepare the crop specific "Standard Operational Procedures (SOPs)" for Application of pesticide with Drones.

Composition of the committee :

1. Dr. Indra Mani, Vice Chancellor, Vasant Rao NaikMarathwadaKrishiVidhyapeeth, Parbhani (Maharashtra) [**Chairman**]
2. Er. C. R. Lohi, Deputy Commisioner (M&T), Krishi Bhawan, New Delhi [**MemberSecretary**]
3. Dr. Archana Sinha, Joint Director, Plant Protection division, DA&FW, New Delhi [**Membe**r]
4. Dr. R. N. Sahoo, Principal Scientist, Division of Agricultural Physics , IARI, New Delhi[**Membe**r]
5. Dr. Sunil D. Gorantiwar, Professor and Head Agril. Engg., MPKV, Rahuri [**Membe**r]
6. Dr. A. Sambaiah, Sr. Scientist (Ag. Engg.) ANGRAU), Guntur, AP [**Membe**r]
7. Dr. Dilip Kumar Kushwaha, Scientist, Division of Agricultural Engineering, IARI, New Delhi [**Membe**r]
8. Dr. S. Pazhanivelan, Director, Water Technology Centre, TNAU, Coimbotore, TN [**Membe**r]
9. Dr. Ram Gopal Verma, Entomologist, PJTSAU, Hyderabad,Telangana [**Membe**r]

As per the office memorandum, the Chairman of the committee may consult any expert from the Drone and Pesticide Industries, SAUs and ICAR Institutes, IITs, etc. Accordingly, Chairman co-opted the following experts from ICAR institutes, SAUs and , Industry -

1. Dr. Roaf Ahmad Parray, Scientist, Division of Agricultural Engineering, ICAR-IARI, New Delhi
2. Dr. Subhash Chander, Director, ICAR - National Centre for Integrated Pest Management, Pusa Campus, New Delhi
3. Dr. V. K. Baranwal, Professor Emeritus (ICAR) , Division of Pathology, ICAR-IARI, New Delhi
4. Dr. Sushil Desai, Crop Science Division, Bayer Crop Science Ltd, New Delhi
5. Dr N.K. Bhute, CAAST-CSAWM, MPKV, Rahuri, Maharastra
6. Dr. Anoop Kumar Upadhyay, IoTech World, Gurugram, Haryana

Terms of Reference

a. The crop-wise SOPs will be developed as an extension to the existing SOP (for use of Drone Application with pesticides for the crop protection and for spraying soil and crop nutrients in Agricultural, Forestry, Non crop areas) of Ministry of Agriculture & Farmers Welfare, Government of India, which will include the technical operational and safety requirements to ensure the safe, efficient and effective use of inputs and the technology.

b. The committee will complete the work and submit the final draft of the SOPs on or before 30th September 2022.

c. The chairman of the committee may consult any expert form the Drone and Pesticide Industries, SAUs and ICAR Institutes, IITs, etc.

2.

Methodology for collection of information on drone based spraying application for development of SOPs

The methodology followed for data collection for preparation of crop specific Standard Operating Procedures (SOP) involved scientific deliberations and information collection through online survey schedule. The committee members along with co-opted members and industry representatives held many 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. The survey schedule contained detailed information about the experimental location, environmental conditions, chemical formulations, drone and spraying systemspecifications, operational conditions, observational parameters, phyto-toxicity, bio-efficacy and other critical observations (Proforma: Annexure-I). The developed survey schedule was sent to different SAU'S, ICAR Institutes and private industries for submission of experimental data related to drone assisted chemical application carried 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 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(Annexure-II). The information received was systematically arranged and classified crop-wise and pesticide wise. Overall, the information was received for nine major crops i.e. rice, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean and sugarcane.

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 focuses 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.

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3. Crop Specific SOPs **for selected nine crops**

The data was received for nine major crops i.e. rice, maize, cotton, groundnut, pigeon pea, safflower, sesame, soybean and sugarcane. Based on the available information, 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), ambient conditions & location (temperature, humidity, wind speed and climatic zone) with major emphasis laid on performance parameters (bio-efficacy and phytotoxicity). The crop specific SOPs were developed considering a standard drone with tank capacity of 10 liters and overall weight of the drone 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 save the environment. However, the turbulence created by drone should not lead to lodging of crop. 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 Annexure –II. As per the data received for different crops, no crop damage or phytotoxicity was observed at tested concentrations of the selected pesticides () at different doses (1X and 2X) and their respective combinations when sprayed using drones. The experiments in above regard were conducted in Southern Plateau and Hills, Trans – Gangetic Plains Agro-climatic region by selected institutes.

Crop Specific SOPs

Table-1(A) : Crop Specific SOP for rice

1. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm - 6pm
Winter season:	8am-11 am & 2pm-6pm
*Strictly avoid spraying during flowering stage	6am -11am
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	Yes
Sloppy terrain: Use terrain following sensors	Yes

Safety requirements for efficient and effective use of the inputs

- Do not spray crop with pesticides during flowering. Pesticide can damage flower resulting in empty grains and also kill beneficial insects. If necessary to spray (unevenflowering + milk stage) it should be done during colder parts of the day when flowers are closed.

Table-1(B): Crop Specific SOP for cotton

1. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm - 6pm
Winter season:	8am-11 am & 2pm-6pm
*Strictly avoid spraying during flowering stage	-
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Safety requirements for efficient and effective use of the inputs

- Avoid chemical insecticides during the first two months of the crop**.** During initial phase of crop growth, natural enemies prey on sucking pests as well as eggs of lepidopteran pests. Avoiding chemical sprays during this period helps to conserve naturally occurring biological control agents that help to keep pest population under check.
- Do not use WHO Class 1a and Class 1b insecticides (Extremely and Highly hazardous category).
- **Avoid Pyrethroids** during the first 4 months after sowing. Pyrethroids may be used only late in the season as one or at the most two sprays for the control of pink bollworm.

- **Not to spray against minor lepidopteran insects** such as the cotton leaf folder, *Syleptaderogata*and cotton semilooper, *Anomisflava*. These insect larvae cause negligible damage to cotton but serve as hosts for parasitoids such as *Trichogramma*spp., *Apanteles*spp and *Sysiropaformosa*, that attack *H. Armigera*and other bollworms.
- **Minimum foliar sprays of neonicotinoid insecticides** such as Acetamiprid, Imidacloprid, Clothianidin and Thiomethoxam which are likely to aggravate insect resistance, since Bt cotton hybrid cotton seeds are treated with neonicotinoids.

Table-1(C): Crop Specific SOP for maize

. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/m)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm - 6pm
Winter season:	8am-11 am & 2pm-6pm
*Strictly avoid spraying during flowering stage	6am -11am
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Safety requirements for efficient and effective use of the inputs

- As the larvae of Army worm are active at night, spraying in the evening is more advantageous.
- Spraying chemical insecticides early in the crop cycle are most likely to kill off the natural enemies and may not be economical.
- **Precautions for pesticide use:** Not more than two chemical sprays are to be used in entire crop duration. Same chemical should not be chosen for second spray. Sprays should always be directed towards whorl and applied either in early hours of the day or in the evening time.

Table-1(D): Crop Specific SOP for groundnut

1. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm - 6pm
Winter season:	8am-11 am & 2pm-6 pm
*Strictly avoid spraying during flowering stage	-
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Safety requirements for efficient and effective use of the inputs

- In case of pests which are active during night like Spodoptera spray recommended biocides chemicals at the time of their appearance during dusky hours.

Table-1(E): Crop Specific SOP for pigeon pea

1. Drone Flying Speed (m/s)	
During spraying	4.0-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (l/m)	0.3-0.6
Angle:	60-120
Swath:	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm - 6pm
Winter season:	8am-11 am & 2pm-6pm
*Strictly avoid spraying during flowering stage	6am -11am
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Safety requirements for efficient and effective use of the inputs

- Do not spray in hot or windy conditions.

Table-1(F): Crop Specific SOP for safflower

1. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm - 6pm
Winter season:	8am-11 am & 2pm-6pm
*Strictly avoid spraying during flowering stage	6am -11am
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Safety requirements for efficient and effective use of the inputs

- In case of pests which are active during night spray recommended biopesticides/ chemicals at the time of their appearance in the evening.
- Do not spray pesticides at midday as most of the insects are not active during this period.
- Emulsifiable concentrate formulations should not be used for spraying with battery operated ULV sprayer
- Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed.
- Safflower is basically self-pollinated but bees or other insects are generally necessary for optimum fertilization and maximum yield so insecticide spray should be avoided at flowering.

Table-1(G): Crop Specific SOP for sesame

1. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm- pm
Winter season:	8am-11am & 2pm-6pm
*Strictly avoid spraying during flowering stage	6am -11am
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Table-1(H): Crop Specific SOP for soybean

1. Drone Flying Speed (m/s)	
During spraying	3.5-4.5
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	1.5-2.5
Varieties prone to lodge	2.0-2.5
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm- pm
Winter season:	8am-11 am & 2pm-6pm
*Strictly avoid spraying during flowering stage	6am -11am
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Safety requirements for efficient and effective use of the inputs

- Spray operation should be carried out either in morning or late evening hours, as during day time larvae of Spodoptera hide in the soil crevices. This will also avoid adverse effect on parasitoids and predators
- Although soybean is a self-pollinated crop, pollinators visit soybean fields regularly during the crop's flowering stage. These pollinators are at danger from insecticide sprays; so follow pest management strategy, avoid spraying or little insecticide should be sprayed at flowering.

Table-1(I): Crop Specific SOP for sugarcane

1. Drone Flying Speed (m/s)	
During spraying	4.5-5.0
During turning, RTL etc.	<5.5
2. Height above crop canopy (m)	
Good standing crops	3.0-4.0
Varieties prone to lodge	-
3. Water volume (l/ha)	
Stage-1 : Early stage	20
Stage-2: Full canopy stage	25
4. Nozzles	
Type of nozzle	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350
Droplet Size (µm): Fungicide	250-350
Nozzle discharge rate (litre/min)	0.3-0.6
Angle:	60-120
Swath(m):	3-6
Number of nozzles:	4-6
Pressure(bar):	2-3
5. Suitable Time of spray	
Summer and rainy season:	6am -10 am & 3pm-6pm
Winter season:	8am-11am & 2pm-6 pm
*Strictly avoid spraying during flowering stage	-
6.Environmental conditions	
Temperature	< 35°C
Humidity	> 50%
Wind speed	< 3m/s
During rain	Don not spray
If visibility during Fog/mist is not good	Do not operate
7.Site Specific	
Plain land: Take care of obstacles present in the field	yes
Sloppy terrain: Use terrain following sensors	yes

Table-2: Summary sheet of SOPs for selected nine crops

S.No.	1	2	3	4	5	6	7	8	9
	Rice	**Cotton**	**Maize**	**Groundnut**	**Pigeon pea**	**Safflower**	**Sesame**	**Soybean**	**Sugarcane**
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	4.5-5.0
During turning, RTL etc.	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5	<5.5
2. Height above crop canopy (m)									
Good standing crops	1.5-2.5	1.5-2.5	1.5-2.5	1.5-2.5	1.5-2.5	1.5-2.5	1.5-2.5	1.5-2.5	3.0-4.0
Varieties prone to lodge	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	2.0-2.5	-
3. Water volume (l/ha)									
Stage-1 : Early stage	20	20	20	20	20	20	20	20	20
Stage-2: Full canopy stage	25	25	25	25	25	25	25	25	25
4. Nozzles									
Type of nozzle	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan	Anti-drift Flat fan
Droplet Size (µm): Insecticide	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350
Droplet Size (µm): Fungicide	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350	250-350
Nozzle discharge rate (l/m)	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:	60-120	60-120	60-120	60-120	60-120	60-120	60-120	60-120	60-120
Swath:	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
Number of nozzles:	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
5. Suitable Time of spray									
Summer and rainy season:	6am -10 am & 3pm - 6pm	6am -10 am & 3pm - 6pm	6am -10 am & 3pm - 6pm	6am -10 am & 3pm - 6pm	6am -10 am & 3pm - 6pm	6am -10 am & 3pm - 6pm	6am -10 am & 3pm-pm	6am -10 am & 3pm-pm	6am -10 am & 3pm-6pm
Winter season:	8am-11 am & 2pm-6pm	8am-11 am & 2pm-6pm	8am-11 am & 2pm-6pm	8am-11 am & 2pm-6 pm	8am-11 am & 2pm-6pm	8am-11 am & 2pm-6pm	8am-11am & 2pm-6pm	8am-11 am & 2pm-6pm	8am-11am & 2pm-6 pm
*Strictly avoid spraying during flowering stage	6am - 11am	-	6am - 11am	-	6am - 11am	6am - 11am	6am - 11am	6am - 11am	-
6.Environmental conditions									
Temperature	< 35°C	< 35°C	< 35°C	< 35°C	< 35°C	< 35°C	< 35°C	< 35°C	< 35°C
Humidity	> 50%	> 50%	> 50%	> 50%	> 50%	> 50%	> 50%	> 50%	> 50%
Wind speed	< 3m/s	< 3m/s	< 3m/s	< 3m/s	< 3m/s	< 3m/s	< 3m/s	< 3m/s	< 3m/s
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
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
7.Site Specific									
Plain land: Take care of obstacles present in the field	yes	Yes	Yes	Yes	yes	yes	Yes	yes	yes
Sloppy terrain: Use terrain following sensors	yes	Yes	Yes	Yes	Yes	yes	Yes	yes	yes

Table-3: 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, Propiconaozole 25EC, Kresoxim methyl 44.3SC, Chlopyriphos 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

*For the maize and sapflower 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 phtotoxicity and bioefficacy data was not available).

General Guidelines for pest management in crops with drone assisted spraying

- 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. More preference should be given to green labeled insecticides.
- Alternate different insecticide classes: Avoid the repeated use of the same insecticide, insecticides in the same chemical class, or insecticides in different classes with same mode of action and rotate/alternate insecticide classes and 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 biopesticides/chemical insecticides judiciously after observing unfavourable P: D ratio and when the pests are in most vulnerable life stage. Use application rates and intervals as per label claim.
- Use protective clothing, facemask and gloves during preparation and application of pesticides.
- Enter the field only 48 hours after spraying pesticide.Interval between application of chemical insecticide and harvest of maize corn should be minimum 30 days

Annexure-I

Ready-Reckoner to determine drone flying and spraying parameters

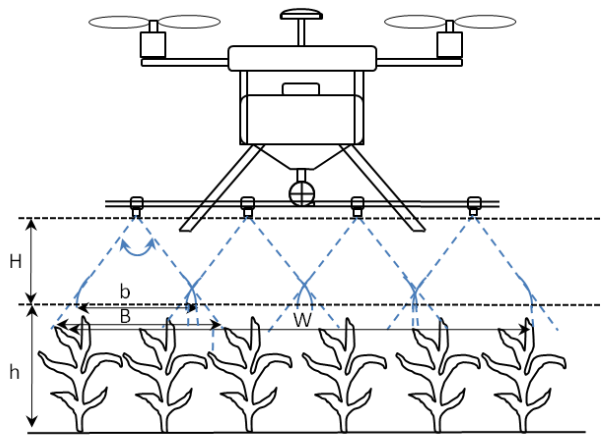
Following table may be used as ready reckoner to set the drone flying speed for uniform spray applying based on swath, nozzle discharge and water volume per ha.

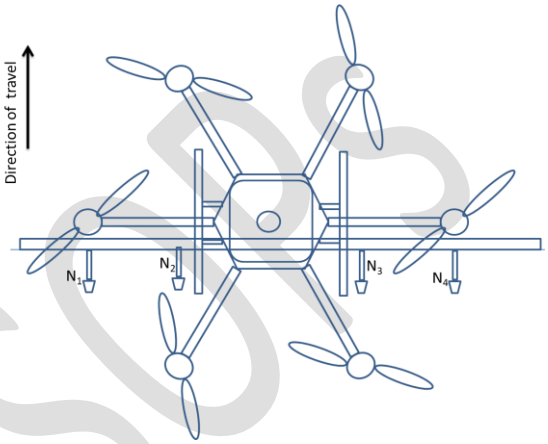
- Evaluate the discharge rate of nozzles (lit./min),Count the no. of nozzles
- Know the swath(cm) of the Drone at known height of spraying.
- Decide o nvolume (lit.)of spraysolution(water+pesticide formulation) to be sprayed per ha.
- Work out the speed(m/s)of the Drone to be maintained during spraying.
- Calculate the time required to spray one acre

Swath(Cms)		300	300	400	400	500	500	600	600
WaterVolumeper		16	20	16	20	16	20	16	20
Lt/min	Nozzles								
0.300	4	4.17	3.34	2.78	3.13	2.50	2.09	2.50	2.00	1.67
0.350	4		2.09	1.67	1.39					
0.400	4	4.87	3.89	3.24	3.65	2.92	2.43	2.92	2.34	1.95
0.450	4		2.43	1.95	1.62					
0.500	4	5.56	4.45	3.71	4.17	3.34	2.78	3.34	2.67	2.22
0.550	4		2.78	2.22	1.85					
0.600	4	-	5.00	4.17	4.69	3.75	3.13	3.75	3.00	2.50
0.300	6	-	5.00	4.17	4.69	3.75	3.13	3.75	3.00	2.50	3.13	2.50	2.09
0.350	6	-	-	4.87	5.47	4.38	3.65	4.38	3.50	2.92	3.65	2.92	2.43
0.400	6	-	-	5.56	-	5.00	4.17	5.00	4.00	3.34	4.17	3.34	2.78
0.450	6	-	-	-	-	-	4.69	-	4.50	3.75	4.69	3.75	3.13
0.500	6	-	-	-	-	-	5.21	-	5.00	4.17	5.21	4.17	3.48
0.550	6	-	-	-	-	-	-	-	5.50	4.59	5.73	4.59	3.82
0.600	6	-	-	-	-	-	-	-	-	5.00	-	5.00	4.17

Swath at different operational heights and spray angles of nozzles

(a) Drone with boom sprayer

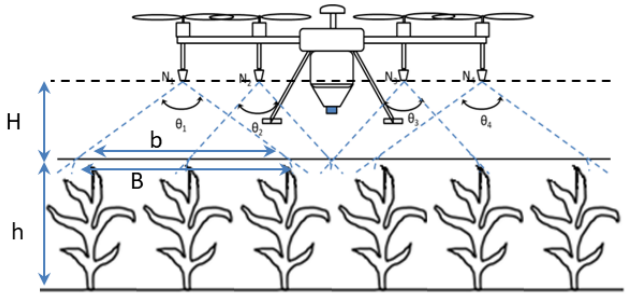


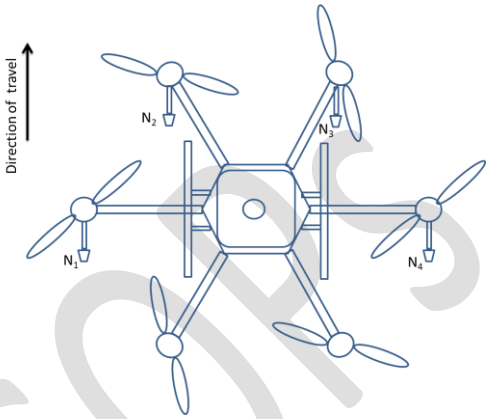


H= Drone nozzle height from the crop canopy
h = Crop canopy height
b= effective coverage of nozzle
B = Theoretical coverage of nozzle
W = swath width of sprayer

	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**
45	1.24	1.33	1.41	1.49	1.57	1.66
60	1.73	1.85	1.96	2.08	2.19	2.31
90	3.00	3.20	3.40	3.60	3.80	4.00
120	5.20	5.54	5.89	6.24	6.58	6.93

(b) Drone with nozzles below the propeller





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

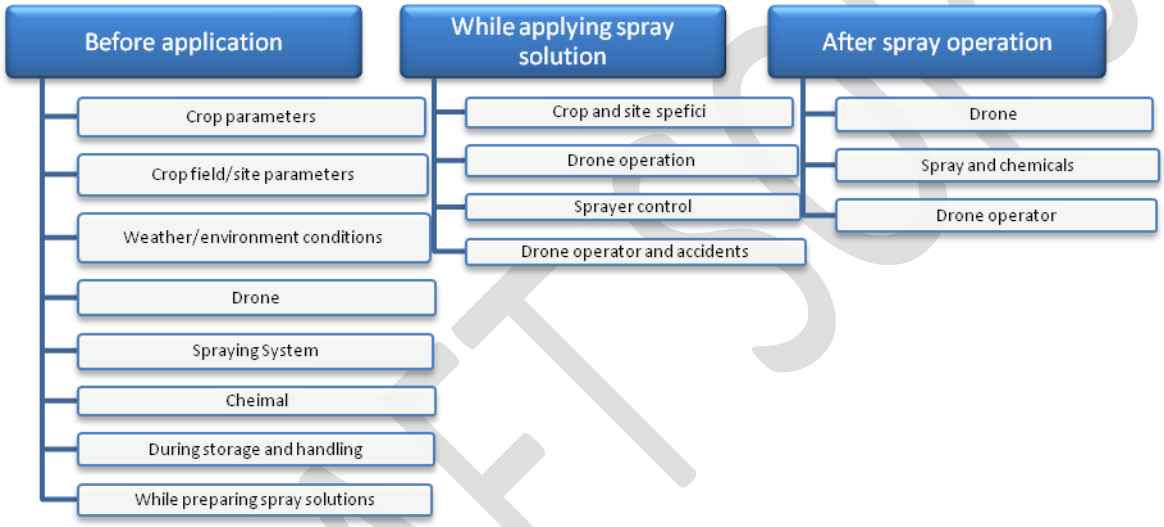
Nozzle	Spray Angle (Degree)
N_1	60-120
N_2	60-90
N_3	60-90
N_4	60-120

Annexure-II

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 chemical using drone	
Crop Parameters: ☑ 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 suitable for mono cropping pattern.	✖ Avoid chemical spray during pollination stage. ✖ Avoid using drone if crop is more susceptible to lodging. ✖ Avoid chemical spray using drone if rain is forecasted. ✖ Respect PHI of the crop ✖
Crop Field:Site parameters ☑ 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. ☑ Check GPS connectivity and stability status ☑ Check shape of the field whether drone can be used or not. ☑ The large crop field should be divided into small patches	✖ Do not plan for chemical spray using drone if field comes under red zone. ✖ Do not plan for chemical spray 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 distance of 100m from these bodies. ✖ Do not plan for a large field spraying using drone to avoid risk of signal loss between remote control and the drone.

for spraying using drone. ☑ Check terrain conditions (Slope, Plain or hilly). ☑ 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. ☑	
Weather/Environment conditions: ☑ Note down the date and time for spraying on log book. ☑ Check the temperature and plan for spray if temperature is less than 35 °C. ☑ 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 8 km/h. ☑ Check the wind direction and according fix the starting home point of the drone for flying. ☑ Consider the weather forecastand take the decision accordingly for drone flying.Cloudy conditions would deter GPS connectivity	✖ Do not plan for chemical spray using drone if temperature is more than 35°C. ✖ Do not plan for chemical spray using drone if humidity is less than 50%. ✖ Do not plan for chemical spray using drone if wind speed is more than 8km/h. ✖ Do not plan for chemical spray using drone if the rain is expected within 4 hours.
Drone: ☑ Always have motor, propeller, ESC and battery in spare. ☑ Note down the drone type and payload capacity. ☑ The drone should be capable of flying in both Manual and Auto mode interchangeably. ☑ Calibrate the drone and ensure the good stability during operation. ☑ Check chemical feeder pipes to the nozzle for airlocks ☑ Ensure the nozzles are free from clogging and dry chemical flakes ☑ 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, --- etc. ☑ Optimise the range drone speed. ☑ Check remote control range and battery 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. ☑ Ensure your drone (except Nano in uncontrolled airspace upto 50 feet) is Digital Sky “No Permission- No Take off" (NPNT) compliant. ☑ 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 Unmanned Aircraft Operator Permit (UAOP), if applicable from DGCA for commercial operations and keep it handy. ☑ Obtain permission before each flight through Digital Sky Platform which will be available on DGCA website from December 1. ☑ Keep an eye on interference which can be from mobile	✖ Do not fly drone if battery are not in good condition and charged. ✖ 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 from the ground level. ✖ Don’t fly drone near other aircraft (manned or unmanned). ✖ Don’t fly drone near airports and heliports. ✖ Don’t fly drone over groups of people, public events, or stadiums full of people without permission. ✖ Don’t fly drone over government facilities/military bases or over/ near any no-drone zones. ✖ Don’t fly drone over private property unless permission is given. ✖ Don’t fly drone in controlled airspace near airports without filing 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.

devices or blockage of signals. ☑ Fly only during daylight (after sunrise to before sunset). ☑ Fly in good weather: Good weather lets you not only fly your drone better but also keep track of it when it is airborne. ☑ Fly in 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. ☑ Keep local police informed about your drone flying activity. If you are ever approached by police provide all requisite information. ☑ Do log your flights and intimate concerned authorities (like DGCA, local police etc.) of any incidents/ accidents	
Spraying system ☑ Check the tank capacity and its cleniness ☑ Note down the pump flow rate capacity and set the pressure as per recommendation or as per mentioned in manual to operate the nozzle assembly ☑ Note down the number of nozzles and check the nozzles are not jam. ☑ 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 working and control through remote control. ☑ Check 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 pesticide should in the range of 150 to 200 microns ☑ The droplet size for weedicide application should be in the range of 200 to 300 microns	✖ 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.
Chemical: ☑ 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.	✖ Do not purchase pesticides from unregistered dealers or from un-licensed person. ✖ Do not purchase pesticide in bulk for whole season. ✖ Do not purchase pesticides without approved label on the containers. ✖ Never purchase expired pesticide. ✖ Do not purchase pesticides whose containers are leaking/loose/ unsealed.
During Storage:. ☑ 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	✖ Never store pesticide in home premises. ✖ Never transfer pesticides from original to another container. ✖ Do not store insecticides with weedicides. ✖ Ensure Crop protection chemicals are stored in lock and key ✖ Do not allow children to enter the storage place. ✖ Pesticides should not be exposed to sunlight or rain water.

sunlight and rain.	
While handling: Keep pesticides separate during transportation ☑ Bulk pesticides should be carried tactfully to the site of application.	✖ Never carry/transport pesticides along with food/fodder/other eatable articles. ✖ Never carry bulk pesticides on head, shoulder or on the back.
While preparing spray solution: ☑ Always use clean water. ☑ 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. ☑ Granular pesticides should be used as such. ☑ 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.	✖ Do not use muddy or stagnant water. Never prepare spray solution without wearing protective clothing. ✖ Do not allow the pesticide/its solution to fall on any body parts. v Never avoid reading instructions on container's label for use. ✖ 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.
While applying spray solutions	
Crop and site specific ☑ Mark the boundary corners of the crop field using flag or mirrors. ☑ Check if any other drone operator is flying the drone nearby fields.	✖ Do not fly drone without marking boundary corner of the crop field. ✖ Do not fly drone very close to the crop canopy. It may cause crop lodging. ✖ Animals should not be allowed to enter into the field during operation.
Drone operation ☑ Keep eye on drone stability during operation. ☑ Keep drone with in the visible range. ☑ Take care of obstacles in the crop field. ☑ Take care of overlap percentage of swath. ☑ Take care drone is flying with in the periphery of crop field. ☑ Drone should have emergency landing option during battery discharge ☑ Keep spare charged batteries for emergency.	✖ 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 --- percentage or less than ----- percentage. ✖ Do not spray if the nozzles are jammed. ✖ Do not allow drone to enter another crop field.
Sprayer control ☑ Apply only recommended dose and dilution. ☑ Spray operation should be conducted on cool and calm day. ☑ Spray operation should be conducted on sunny day in general. ☑ Use recommended spraying combination for each mission ☑ Spray operation should be conducted in the wind direction. ☑ After spray operation, sprayer assembly and other equipment used during the operation should be washed with clean water using detergent/soap.	✖ Never apply over-dose and high concentrations than recommended. ✖ Do not spray on hot sunny day or strong windy conditions. Do not spray just before rains and immediately after the rains. ✖ Do not spray against 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 immediate after spray without bearing protective clothing

Drone operator and accidents ☑ Drone operator must wear the PPEs during spraying operation ☑ Remote control should be in hand of the operation even if the drone is in auto mode. ☑ Drone operator should cover his eyes with goggles to avoid chemical exposure. ☑ Drone operator should inform to local police if drone crashed accidently and it should recoded in log book with proper reason of accidents. Take also the photographs of the accident. ☑ Operator has to apply for insurance claim as soon as possible.	. ✖ Drone operator should not remove the PPEs during spraying operation ✖ Drone operator should not remove safety goggles during operation. ✖ 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:	
General ☑ Avoid the entry of animals/workers in the field immediately after spray.	✖ Do not irrigate the field just after spraying of chemicals ✖ Do not harvest the crop just after spraying for fodder. ✖ Do not spray the fertilizer just after chemical spray
Drone ☑ Take out the battery from the drone and put 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 intransportation box/bag.	✖ Do not expose the battery terminal point to avoid short circuiting. ✖ Do not forget the drone and its accessories in the field after spraying
Sprayer and chemicals ☑ 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.	✖ 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 lines etc. ✖
Drone Operator ☑ Clean the PPE after use ☑ Wash hands and face with clean water and soap before eating/smoking. ☑ On observing poisoning symptoms give the first aid and show the patient to doctor. Also show the empty container to doctor.	✖ 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

Annexure-III

Suggested Proforma for collection of information for developing crop specific SOP by different institution during drone assisted pesticide application experiment

As the experimental data was available for only nine crops, therefore, committee developed SOPs for those nine crops only. There is a need to generate data on remaining crops for development of SOPs . The committee also prepared a proforma for information collection during assisted spraying experiment.

Note: The proforma may be filled for each spraying operation and for each crop separately. Incase replicated data then use single sheet with one replication each coloumn

		R1	R2	R3
1.	**Experimental Site Details**			
i.	Location (Latitude, Longitude, Altitude)			
ii.	Approximate distance of nearest obstacle (tree, pole, wall, building etc) from the starting point of drone (m)			
iii.	Shape of each plot			
iv.	Total area covered during the experiment			
2.	**Crop and Chemical Information**			
i.	Name of the Crop			
ii.	Crop Variety			
iii.	Crop spacing (between rows x between plants):			
iv.	Crop height at the time of spraying:			
v.	Growth stage of crop			
vi.	Name of the target disease /pest			
vii.	Name of the pesticide			
viii.	Type of formulation:			
ix.	Concentration (g ai/lit or % or ml/L)			
x.	Dosage (g/ha or ml/ha)			
xi.	Dosage selection method (Recommended/ Trial based)			
3.	**Environmental Conditions of the Experimental Site**			
i.	Temperature (^{0}C)			
ii.	Wind velocity(km/h)			
iii.	Relative humidity (%)			
iv.	Wind direction (degrees from N)			
4.	**Drone Details**			
i.	Payload (kg)			
ii.	Maximum take-off weight (kg)			
iii.	Drone Type: Small/ Medium/ Large			
iv.	Drone category: Multi-copter, Hybrid, others			
v.	Power Source (Battery/fuel/hybrid)			
vi.	Battery storage (mAh), if battery powered:			
vii.	Fuel type if fuel operated			
5.	**Spraying System Details**			
Maximum tank capacity				

Tank material			
Maximum volume filled at the start of experiment:			
Type of nozzle			
No.of nozzles			
6. <u>Operational Parameters</u>			
i. Height above crop canopy			
ii. Operating pressure of spraying sytem			
iii. Nozzle flow rate (lit/min)			
iv. Flying speed (m/sec)			
v. Flying direction (degrees from N)			
vi. Spraying type (a) Uniform (b) Variable rate spraying			
vii. if variable rate spraying, then variations a. In spatial scale and /or b. Spray rate			
viii. How the decision is made for site specific spray and rate of spray (a) based on crop health monitoring (i) infections levels and (ii) abiotic stress-nutrient stress levels (b) Source of crop health data (i) from ground collected information, eye estimate (ii) from drone based surveillance			
7. <u>Performance Parameters</u>			
i. Droplet size range (µm)			
ii. VMD			
iii. NMD			
iv. Coefficient of Uniformity (%)			
v. Spray width (m)			
vi. Overlap (%)			
vii. Bio-efficacy/mortality *viii. Please mention* ix. Time after treatment (hours) & **x.** Method of efficacy/mortality estimation			
xi. Theoretical field capacity			
xii. Actual field capacity			
xiii. Major time losses			
xiv. Battery operational time			
xv. No. of tank fillings per hectare			
8. Other details			
Any major breakdown during the experiment			
Any major observation during the experiment			
Any adverse effect on non-target organism or crop			

Proforma used for collection of Information

Government of India
Ministry of Agriculture and Farmers' Welfare
Department of Agriculture, Co-operation and Farmers' Welfare
(Mechanization and Technical Division)

The proforma for providing the information required for developing the crop specific Standard Operating Procedure (SOP) 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 1, 3 and 4 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 1. 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 2. 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 3. 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 4. 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)	

5. Formulations sprayed (use appropriate table)

Table 5 (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 5 (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)	

6. Observations

Table 6(A) Environment

Sr. No.	Parameters	Details
1	Temperature (^{o}C)	
2	Relative humidity (%)	
3	Wind speed (km/hr) and direction	

Table 6(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	

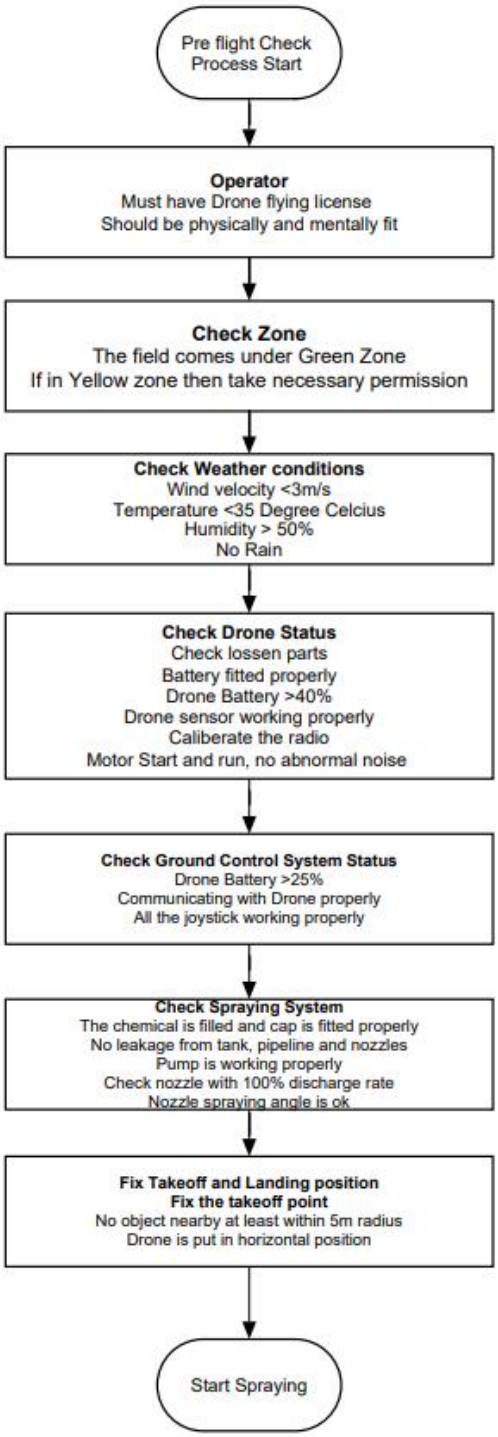
Flight No.	Area (ha)	Time (min)

Table 6(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, muddle 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./cm2)	
	(d) Spray uniformity (%)	
4	Control efficiency (%)	
5	Phyto-toxicity observations/effects	
6	Efficacy	
7	Other observations	

7. Other related information

Annexure-IV: Instructions to be adhered to by the drone operators



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1. Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana
2. Department of Remote Sensing and GIS, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu