OPPORTUNITY OF APPLICATION OF DRONE TECHNOLOGY IN AGRICULTURE-WITH SPECIAL REFERENCE TO PESTICIDE SPRAYING

Abstract

Agriculture as a traditional livelihood, has passed through the cross road of tradition and modern scientific technology during industrial revolution. New regime of non agricultural workforce evolved. Therefore farmers had to took responsibility to feed huge non agricultural workers as well as to cater different raw materials for industrial production. Newly emerged nation had to adopt policy of input intensive production system. These critical inputs were high yielding variety seeds, fertilizer, pesticides and irrigation water. This newly adopted policy is called as green revolution. Though green revolution had broken impasse of poor productivity, but this achievement was not maintained for long run. Factor productivity of different inputs gradually declined due to law of diminishing marginal return. Therefore new innovative intervention is warranted and to be sought to overcome this impasse of nation's agricultural growth. In 2015 the terms '' Fourth Industrial Revolution '' or '' Agriculture 4.0 `' were proposed. It is a paradigm shift from chemical led technology to Information Technology led agriculture. This technology is location specific, wastage minimizing, cost reducing and less prone to environmental degradation and known as precision technology. Drone is an unmanned air vehicle and resemble to aero plane/helicopter. Therefore remote operator is safe from any shorts of pesticide contamination and snake bite. Though it was evolved for military purpose , now it can be used for civil purpose and agriculture. This study aims at different aspects of use of drone in agricultural activities. Drone is now a days used as plant protection equipment to spray pesticides in a consolidated fields in different

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states of India. On the basis of analysis of several empirical studies, different pross and cons of spraying pesticides by drones are enumerated with respect to traditional knapsack sprayer. Standard operating protocols of use of drone are critically studied here.

Keywords: Unmanned Aerial Vehicle, Artificial Intelligence, Precision Farming,

I. INTRODUCTION

Agriculture, which is the most primitive livelihood of the human civilization, has developed by manipulating natural resources with the aid of general intuitive conception on natural laws. This vast reserve of wisdom on natural phenomenon was evolved due to long practice of cultivation. Hence agriculture may be called as deep routed source of natural sciences. This indigenous natural knowledge was passed from one generation to other generation through different folk lore. Though different branches of natural sciences were originated from different age-old practices of agriculture ,still farmers were deprived of application of science and technology . After industrial revolution a new regiment of working force evolved. They shifted their occupation from agriculture sector to industrial sector. Farmers had to take responsibility to feed huge labour force of non-agricultural sector. Moreover, Agriculture was prime sources of several industrial raw materials. During last two centuries, agriculture grew rapidly. This immense achievement became possible due to application of science & technology. To sustain this achievement, productivity of crops as well as fertility of soil had to be maintained by using chemical fertilizers, high yielding seeds, pesticides accompanied by irrigations. After independence of our country, large no's of people were migrated from East & West Pakistan due to partition of our country. Land-Man ratio decreased. Primary motto of the then agriculture was to feed huge crowd and to achieve self-sufficiency in Indian agriculture. Newly emerged nation had to adopt policy of green revolution, which is highly dependent on chemical fertilizer, HYV seeds, pesticides as well as irrigation. Primarily agricultural production increased manifold but after three decades It reaches at plateau. Per unit Factor productivity of different inputs like fertilizer etc. is gradually declining due to Law of diminishing marginal return. Since 1970 total factor productivity improved rapidly to the tune of almost 2 per cent per annum, but after 1990 the total factor productivity has declined to 0.59 per cent per annum. This indicates that improved technology which was introduced during green revolution is no more effective. Excessive use of chemical fertilizers, pesticides has caused havoc pollution in air, water and in our bio sphere. Loss of biodiversity within crop field has caused great threat to the crop cultivation. Due to declining trend in defenders within agro-ecosystem, strategy related to plant protection became difficult. More over rapid urbanization will cause non availability of agricultural labours and cultivable lands. Another important limiting aspect of agricultural growth is the declining per capita land holding. In 1952 India had average 0.33 ha per capita land holding , which is further reduced to 0.15 ha at present . This will limit scope to introduce newer technology in Farmers field. In spite of all limitation, population will grow @ 23.6% during forth coming three decades. To feed this growing population, food production is needed to be grown @ 49.6 % within 2050. Therefore new innovative intervention is warranted and new avenue is to be sought to overcome this impasse of nation's agricultural growth.

II. FROM CHEMICAL LED AGRICULTURE TO PRECISION FARMING

A paradigm shift of technological regime is warranted to overcome existing vicious cycle of high use of chemical inputs, low factor productivity and environment pollution. In 2015, the terms '' Fourth Industrial Revolution '' or '' Agriculture 4.0 `` were proposed. It is a paradigm shift from chemical led technology to Information Technology led agriculture. There is interspatial variability in climate, soil etc. Therefore technology to be advocated should be location specific and suited to the variable environment. Different sophisticated

modern technology like, remote sensing, GIS, GPS based technology, robotics, nano technology are now a days getting importance to augment agricultural production and to minimize loss due to overuse of precious inputs . Artificial Intelligence, big data analytics, precision equipment, cyber based farm management tools are getting gradually popularity. Precision agriculture is a management approach, which helps to identify limiting resources and resolves limitation by using justified amount of limited factors or using it in précised amount. Thus it is helpful to reduce cost in effective manner. Precision agriculture is highly dependent on some sophisticated agriculture tools. Drone is a sophisticated equipment's, which may be used to perform several agriculture activities in précised manner. Therefore, use of drone is also connected with precision farming.

Drone is a form of Unmanned Aerial Vehicle. Drone is abbreviated form of **Dynamic Remotely Operated Navigation Equipment**. It is quiet resemble to aircraft or helicopter, which is driven by a pilot who is controlling the movement of vehicle from remote. Therefore, he is safe from any accidental incidents. It may be called as flying robot. Robots can do several activities going beyond the normal capacities of human being. This is an appliance which possesses Artificial Intelligence.

III. EVOLUTION OF DRONE

In 1847, Austria first sent an unmanned balloon carrying explosive for bombing in Venice. this was the first Unmanned Aerial Vehicle used in War. During the Battle of Neuve Chappelle the British army sent Unmanned Aerial Vehicle for capturing aerial imagery of German bunkers. This drone was used for spying in enemy country .Abraham Kar was the first man, who used unmanned aerial vehicle to used in warfare. He was known as the father of drone. Drone is the forerunner of todays missile .Though drone was evolved to meet up specific need of warfare, , still it is being used in several needful purpose during peace time. Basic useful feature of drone is that which can fly under control of remote pilot. It can fly across the impassable terrain.

IV. CIIVIL USES OF DRONES

Several civil uses of drones are;

1. **Entertainment:** Drone may be used as toy. Particularly nano & micro drones are used as toy.

2. **Shipping & Delivery:** Digitally ordered goods may be effectively & precisedly delivered to the customers "door step by using drone.

3. **Filming & Journalism:** Drone may be important aid to the photo journalist. Photo journalist can capture photo/video from a disturbed area without hampering his own security.

4. **Disaster Management & Rescue Operation:** Drone may be used to capture photographs from disaster affected areas. It may be used in distribution of reliefs to the victims. The victims may be rescued and evacuated from affected place to the shelter.

5. **Geographical Mapping:** Drones can be used to prepare 3D-Map & to study inaccessible terrain & mountain tops.

6. **Wild Life Monitoring:** Wildlife in dense forest can be easily monitored by using drone without disturbing their natural living.

7. **Weather Forecasting:** Drones may be used to study weather parameters. Cyclone can be studied by using drones.

8. **Agriculture:** Drone may play vital role in crop management. It can study soil fertility status, crop health status, livestock health etc. Drone may be used to spray fertilizer & pesticides in efficient manner.

V. CLASSIFICATION OF UNMANNED AIR CRAFT SYSTEM

Unmanned Aircraft Systems are categorized in three classes as per its mode of flight and it's configuration

1) Aero plane like, 2) Helicopter like rotor craft , 3) Hybrid

1. **Aero Plane Like:** It has two fixed wing like common aero plane. It has simple structure and also easy to be maintained. It is more energy efficient and can carry more weight . It can fly for couple of hours. It can fly at high altitude. It's most important disadvantage is that it requires a run way to take off the plane.

2. **Rotor Craft:** This type of drone possesses few number of rotors at overhead. It can be further classified as per no's of rotos present. Quad copters are rotor crafts having four no's of rotors at its over head , whereas Hexa copters have six no's of rotors. Drones used in agriculture are mostly rotor crafts under these two categories.
Multi rotors drones are very easy to control and maneuver. It can hover over a single place and does not require any run way.

It's main disadvantage is that it can fly for a very limited period (10 -15 minutes) and requires frequent charging.

Classification Based on weight & Size: As per weight & size drones are classified as follows;

- **Nano:** upto 250gram
- **Medium:** 25Kilogram to 150 kilogram
- **Micro:** 250gram to 2Kilogram
- **Large:** more than 150 Kilogram
- **Small:** 2Kilogram to 25 Kilogram

This weight is including it's pay loads also.

Figure 1: Aero plane like Drone

Figure 2: Rotor craft Drone(Helicopter Like)

Agricultural Drones are of small/Medium type. It includes tanker having capacity of 10 liter. All Drones should be registered by The Director General Civil Aviation mandatorily except Nano drone. The Director General Civil Aviation shall issue a type certificate. Agriculture Drone should have Type Certificate mandatorily.

VI. PRINCIPLES OF FLIGHT

Four types of forces are acting upon a drone and are responsible for **Flight.**

1. **Thrust:** Force produced due to rotation of Propellor/ Rotor is called Thrust. Thrust pushes the craft to move forward.

2. **Drag:** As per Newton's third law, counter force of the Thrust is Drag.

3. **Lift:** The force, which is opposite to the weight of aircraft is called Lift. It holds the aircraft upward. This is created due to the dynamic effect of air that moves over the airfoil. It acts vertically to the flight path. Lift nullifies the gravitational force of the aircraft.

4. **Weight:** The gravitational force acting upon the drone through it's center of gravity is known as Weight . It is nullified by it's Lift.

Bernoulli's Principle: Wind flows over airfoil is faster than the wind flows below the airfoil. According to Bernoulli's Principle, this creates pressure differential between the upward and downward side of the airfoil. As the upward pressure is greater, it lifts the aircraft/drone upward.

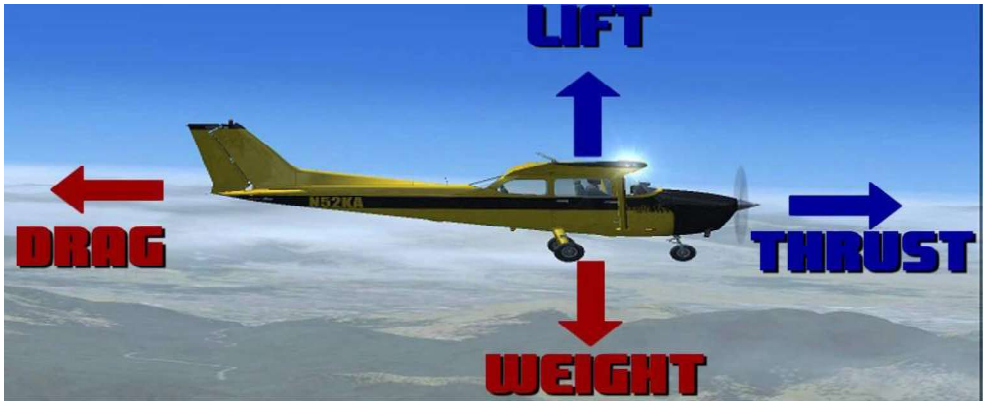

Figure 3: Different forces acting upon air craft

A rotorcraft/Drone can move in six direction with respect to it.s three axis.

Drone can move upward/Downward; PITCH - LATERAL AXIS
Move Leftward/Rightward; YAW - VERTICAL AXIS
Move anticlockwise/Clockwise: ROLL: LONGITUDINAL AXIS

VII. DIFFERENT SPARE PARTS/COMPONENTS REQUIRED FOR AGRICULTURE DRONES

Winged drone requires Runway/Launching station, whereas Rotor Crafts can rise vertically above. Drones are controlled by radio message delivered by transmitter. Remote pilot monitors it's movement through his wireless transmitter. GPS indicator indicates GPS of the drone. Drones' movement can be programmed by its GPS in well ahead of the flight. Accordingly, the drone will take off and can complete its travel by his predetermined routes and timings. After completion of its task, it will return to the position from where it was launched. Two no's of Lithium Polymer batteries having 4.2 Volt and 16000mAh/22000mAh are required for power supply of Quad Copter/Hexa Copter Drones suitable Charging is required within 15 minutes interval. It is better to use battery having capacity of 22000mAh. Rotors/Propellers are rotated by DC Motor. Quad Copter has four rotors.(Two in each side) and a Hex Copter has six rotors (Three in each side). Apart from that, each copter has sensors, cameras etc. Cameras provide information regarding targeted objects through visible spectrum of light(Blue-Green-Red). Wavelength of visible spectrum ranges between 400 nM to 700 nm. There are many wavelengths beyond the visible spectrum of light ,e.g., Ultra Violet Ray , Infra Red Ray etc. This invisible portion of spectrum furnishes more useful information than camera sensing visible light only. Apart from above, there may be several types of sensors, which can sense presence of chemicals, magnet, sound , heat etc. The special accessories attached to perform specific duties of drone ,is called payloads. Agriculture Drone may be used to spray pesticides/fertilizers. Therefore, a tank for keeping pesticide/fertilizer solution and four no's nozzle is being used as payloads. A tank can contain ten liter, which is needed to spray one acre land. Flat pan type nozzle is most efficient to spray on crop canopy.

In single charge of battery, a drone can fly for fifteen minutes. This duration is called one cycle. a battery can run for 300 cycle. Another impotant aspect is that ten minutes required to spray one acre land . Therefore a drone can spray 1.5 acre in its one cycle of charging. One battery costs Rupees Thirty Thousand approx.

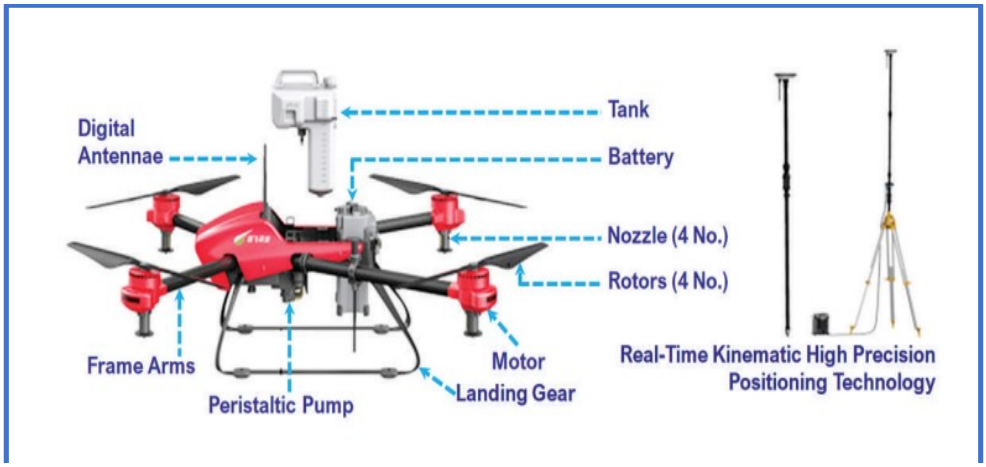

Figure 4: Different Spare Parts of a Drone

VIII. RULES AND REGULATION RELATED TO NAVIGATION OF DRONES

Navigation of drone is very sensitive with respect to the security point of view of a nation. Therefore there is several stringent rules and regulation, which should be followed by drone user. This rule is known as The Drone Rules 2021, published by the Government of India. As per these rules, all drones except Nano drones are required mandatorily to be registered by the Director General Civil Aviation. He shall issue Type Certificate for the drone to the drone holder. This certificate holds Unique Identification Number of Drone.

All drone operators/pilots should have training from any RPAS training school and thereafter should have license to navigate drone. Keeping in view of security, three zones are demarcated to restrict movement of drone in sky. These zones are as follows;-

1. **Red Zone:** This is totally drone prohibited zone.

   - 5 kilometers away from the international Air Port
   - 25 kilometers from international Boundary
   - 500-meter crossing sea coast
   - Any area 400 feet above the ground

2. **Yellow Zone:** Permission is required to move a drone.

   - 8-12 kilometer away from the international Air Port
   - Up to 200 feet in Yellow zone area

3. **Green Zone:** No permission required up to 400 feet height.

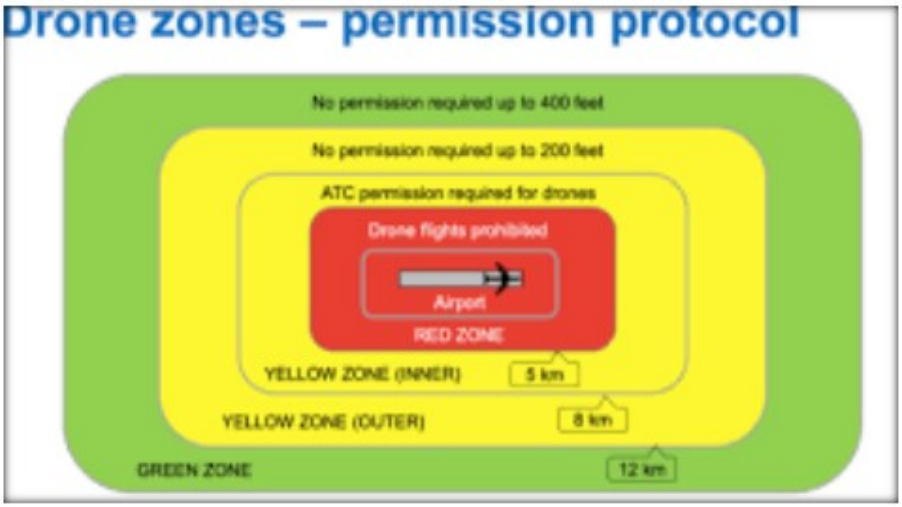

Figure 5: Drone Flight Zones

IX. APPLICATION OF DRONE IN AGRICULTURE

Application of drones in agriculture is gradually increasing throughout the world. According to recent researches the global market of drone is increasing @ 35.9% a compound Annual Growth Rate. Monitory value of its business will reach $5.7 billion by 2025. This emerging technology can help reduce time and increase the efficiencies of the farmers. The use of drones in the agricultural sector is only expected to rise as the industry matures, and so it is good to know how to use this technology judiciously. More over it has capacity to escape obstacles intelligently with it's sophisticated sensors.

Drone may be used in agriculture to meet several purposes arisen due to introduction of precision farming. Several interventions of drone technology in agriculture are as follows.

1. **Soil and Field Planning:** With the aid of several inbuilt sensors, a drone can assess soil moisture availability, erosion, fertility status, nutrient content etc. As per captured image of the soil, nutrient demand for soil.

2. **Plantation:** Drones can help to plant seeds of different trees and crops , where human labour is expensive and unavailable.

3. **Live Stock Management:** Drone can monitor herd of huge livestock. It can also find out lost livestock out of it's herd. It can also detect seek animal with the aid of it's multispectral sensor, so that earliest intervention may be adopted to check the spread of epidemic.

4. **Monitoring of Affected Areas after Natural Calamities:** Sudden blow of natural calamities like flood, cyclone, earthquake and disaster causes affected area inaccessible to the quick response team. Therefore, earliest assessment of the extent of damage becomes troublesome. Drones may be effective tool to access the area and take real time aerial images of the damaged area.

5. **Crop Health Monitoring:** Large scale farming in a vast land requires continuous monitoring. Surveillance of crop health, timely identification of diseased affected plants and rogueing it out is essential to check the spread of diseases and to take earliest intervention from Integrated Pest Management point of view. It is very hard to complete this process manually. There is also scope of human error, which should be minimized. Drone can help a lot in this case. Vast multispectral imagery provides huge information on affected plot. It can also evaluate the condition with the aid of it's artificial intelligence.

6. **Crop Spraying:** Spraying of pesticides and fertilizers to correct plant health related problem in a vast tract of land within a short duration is possible by using drone . It requires less labour , less cost. Pesticides and fertilisers are applied in a precise manner and thus reduce environment pollution. Even operators remain safe from pesticide contamination.

X. EMPIRICAL STUDIES RELATED TO SPRAYING PESTICIDES

Among above mentioned uses of drones , Some research work , extension work has been recently introduced in India and neighboring country of Asia , which are related to spraying of pesticides. Therefore some findings related to spraying pesticides is available in literatures '' Compared to conventional agricultural manned aircraft , UAVs do not require a special airport, and have advantages , such as good mobility , low weight , flexible movement , lower operational cost and complexity , higher spatial resolution.(Bae and Koo,2013, quin et al 2016).

More over Zhang et al 2014, Lan et al 2008, observes that , UAVs are also more adaptable for spraying at low altitude due to geographical restrictions. In addition it can avoid obstacle at its path. Lan et al, 2017 further observed that , hazards of pesticide contamination to the humans(operators) is minimum during the aerial spraying through drones.

There is paucity of research work in India regarding use of drone in agriculture . Most vivid work is done by Professor JayaShankar Telengana State Agricultural university. They had started to execute spraying in the experimental plots since the 21st February,2019. After rigorous experiment in University plots , pilot project was launched at adjacent farmers' fields. On the basis of all above studies, Professor JayaShankar Telengana State Agricultural university published a Standard Operating Protocols for Drone Based Pesticide application''. On the basis of above studies, Ministry of Agriculture and Family Welfare published crop specific Standard Operating Protocols during February,2023. The author of this article is furnishing information on the basis of above studies.

The Telengana State Agricultural University has conducted several experiments to determine ;1) Proper Nozzle type , 2) Optimum Flight Height of Drone , 3) optimum flight speed. Effective spraying is dependent on above three factors Effective spreading is dependent on proper selection of nozzles. Atomization of spray droplets and penetration of spray mixture on crop canopy is also dependent on flight and speed of drone. Five types of nozzles were chosen for the study, eg, 1) Extended Range Plat Pan, 2) cone jet hollow cone, 3) Twinjet- Flood jet wide angle , 4) Air Induction Flat Pan , 5) Air Induction Even Flat spray.

Three levels of flight height were chosen as a treatment, eg, 2 meter , 2.5 meter ,3 meter above crop canopy. Flying speed was kept within 3-5 m/sec, Four nos of nozzles were attached with drone. Spray width was selected 4 meter.

Effects of the above treatments were tested against following parameters;

1) No of droplets, 2) Size of droplets, 3) Coverage of droplets/per square cm . To test these matters bamboo pegs having same height of the crop stands were posted in the field at random , then three no's of blotting papers were attached with the peg in three different depth, e.g. at the almost bottom of crop stand , at the middle of the crop stand and lastly upper portion of the crop stand . Then several drones were flown at different height and different speed and was attached with all five types of nozzles and sprayed water upon the crop canopy. After spraying on crop, no of droplets, size of droplets, coverage of droplets fallen on blotting papers were enumerated.

The study revealed that more smaller droplet size covered maximum area as it possesses maximum surface area. Better spread was obtained spraying by Extended range Flat Pan nozzles.

Low flight height(<2meter) causes turbulence in crop canopy due to revolution of rotors. Therefore spread of droplets are not properly made.

High flight height(> 3 meter) :- Droplets are drifted by wind at higher extent , if it is sprayed over 3 meter height. Therefore optimal flight height for good spread of pesticide droplets is 2.5 meter. Optimum flight speed should be 2.8 -4.4 m/sec.

Figure 6: Drone Spraying Pesticides Over Crop Field

Separate experiment was made to spray different molecules of pesticides are sprayed against different insects and diseases. As a control spray by battery operated knapsack sprayer es adopted. Moreover counts of several defenders and avian population was taken. Pesticides sprayed are of mostly new molecules and having specific target. No adverse effect on defenders and avian population was observed. Pesticide was sprayed at recommended dose in

full in terms of gram/ha . It was diluted with 25 liter water per hectare for young plants which did not crossed tillering stage and 40 liter water per hectare at maturity stage. Therefore it was ultra low volume spray. Recommended dose was not reduced so that pesticide resistance can not get scope to evolve.

XI. COMPARATIVE ANALYSIS OF ADVANTAGE OF SPRAYING BY DRONE OVER SPRAYING BY KNAPSACK SPRAYER

Farming community of West Bengal uses knapsack sprayer to spray pesticides in crop field. They are affected by contamination of pesticides directly. More over death by snakebite during spraying of pesticides is very common feature. This awkward incidence can be avoided by using drone.

A large tract of land can be sprayed by drone within very short duration. A drone can spray 2 hectare of land per hour, whereas 0,12 hectare land can be sprayed within one hour by ordinary knapsack sprayer. Therefore speedy spray by drone can check spread of diseases and insects in time. So effective control of pests is feasible by using drone as spraying equipment.

Drone minimizes requirement of water during spraying . 25 -40 liter water requires to spray one hectare land by drone. The quantity of water is subjected to the growth stage of crops. Spraying manually by using knapsack sprayer requires 300-500 liter of water for one hectare land.

Drone creates mist like atomized water droplet Tiny water droplets have more surface area, hence it covers more area. Therefore no tiny spore of pests can not avoid clutch of pesticide particle. So efficacy of spraying by drone is higher than spraying by knapsack sprayer.

It is convenient to spray by drone in orchard of fruit tees and plantation crops with higher elevation. Spraying in rough terrain is also convenient by drone rather than spraying by knapsack sprayer.

XII. CONSTRAINTS OF USE OF DRONE TO SPRAY PESTICIDES R

Apart from several advantages as discussed earlier, there are some constraints in application of drone to spray pesticides. Particularly state like West Bengal is dominated by small and fragmented holding. This will cause impediment to introduce drone as a popular agricultural equipment.

Secondly a drone requires frequent charging for flight at fifteen minutes interval. Each time charging is called one cycle. Life of a battery is limited for 300 cycles. One set of battery contains two cells, each cell costs almost Rupees thirty thousand . Therefore battery cost is a limiting factor.

All of these above constraints will be solved , if farmers are clustered under Farmers Producers company. Collective efforts will cross all limitation and thus will achieve profit through economy of scale principle.

XIII. DIFFERENT RECOMMENDATION RELATED TO USE OF DRONE TO SPRAY PESTICIDES

There is a very limited study regarding use of drone in India. Only Telengana State Agriculture University has published their results in this regard. They have conducted their experiment on seven crops. The Telengana State agriculture University has published a Standard Operating Protocol on spraying by drone as a plant protection equipment. During February 2023 , Ministry of Agriculture and Family Welfare and ICAR has published detailed Standard Operating Protocol on pesticide spraying by drone on ten selective crops.

Therefore essence of those SOPs is highlighted below: Effectiveness of pesticide spraying is dependent on three factors, eg, 1) Selection of nozzle, 2) optimum flight height of drone over crop canopy 3) optimum speed of drone.

Flat Pan nozzle is most effective for uniform spread of pesticide solution on crop canopy as a tiny mist like droplets. Optimum diameter of droplets is enumerated 250-350 micron.

Optimum flight height is enumerated 2.5 m from crop canopy . Optimum flight speed is 3-4 m/sec .Optimum flight height and flight speed are the determinants of good spread of pesticide solution on the crop canopy.

Pesticides to be sprayed during Morning 6-00 am -9-00 am and in afternoon within 3-00 pm – 6-00 pm. If bee population is seen to fly on crop canopy, then spraying should be stopped. No spraying is permitted if population of defenders and beneficial insects are abundant in the field. Therefore principle of IPM should be strictly followed . Continuous surveillance is to be followed before spraying. .Drone also can be used to monitor crop health by it's multi spectrum sensors. if Pest: Defender ration exceeds 2:1 , then chemical intervention is only permitted. Biopesticide like NPV/BT solution can be sprayed by drone. Pesticides are to be sprayed at recommended doses in terms of gram/ha. Quantity of Wate which is required to be diluted. The recommended dose ranges between 25liter- 40 liter/hectare. The requirement of water is subjected to crop stage

XIV. STANDARD OPERATING PROTOCOL OF SPRAYING PESTICIDE BY DRONE

Ministry of Agriculture and Family Welfare has published SOP on pesticide spraying by drone, which are as follow;-

- Drones should be registered by DGCA. License of Pilot is also mandatory.
- Drone should be capable to avoid any obstacle on his path , like high building , tree or wall.
- Drone should not fly at Drone Prohibited area like Red Zone etc.
- Nearest Police station and Local Agriculture office should be intimated well before it's schedule of flight.
- Drone should avoid congested residential area.
- All herd of cattle should be evacuated from intended plot for spraying.

- Flight of drone should be avoided during unfavorable weather, like high speed wind and rain.
- GPS connection and connection with it's remote should be uninterrupted.
- Drone should not be flown out of sight of it's operator.
- Provision of charging battery should be arranged at the place, where the drone is flown
- Five meters margin should be maintained from the border of other unwilling farmers.

XV. SOME CROP BASED RECOMMENDATION OF PESTICIDES

A few crop wise recommendation for seven no of crops has been made by Telengana State Agriculture University, which is stated below.

Table 1: Crop Based Pesticide Recommendation

Crop	Pest	Pesticides	Dose Recommended	Remarks
Paddy	Stem borer	Chlorantraniloprole18.5C	150ml/ha	Upto Panicle Initiation
		Acephate50 + Immidachloprid1.8SP	750g/ha	Reproductive stage
	BPH	Pymetrozine50WG	300g/ha	
	Blast	Propiconazole25EC	500ml/ha	
	Grain Discoloration	Tebuconazole25 + Trifloxistrobin50 (75WG)	300g/ha	
Cotton	Aphid/Jassid/ Sucking insect	Flonicamid 50 SG	150g/ha	
	Pink Ball Worm	Spinetorum11.5SC	450ml/ha	
	Leaf spot	Tebuconazole25 + Trifloxistrobin50(75WG)	300g/ha	
Red Gram	Pod Borer	Chlorantraniloprole18.5C	150ml/ha	
	Alternaria Leaf spot	Metrium55 + Pyraclostrobin5(60WG)	1500g/ha	
Soyabean	Leaf eating caterpillar	Chlorantraniloprole18.5C	150ml/ha	
	Anthracnose	Carbendazim12 + Mancozeb63WP	1250g/ha	
Groundnut	Spodoptera	Chlorantraniloprole18.5C	150ml/ha	
	Leafhopper	Thiamethoxam25WG	250g/ha	
Sesame	Leaf Webber and capsule borer	Chlorantraniloprole18.5C	150ml/ha	
	Powdery mildew	Myclobutanil10WP	500g/ha	

Source: Telengana State Agricuture University

XVI. CONCLUSION

Application of artificial intelligence, robotics and drone technology has immense prospect in agricultural development. Considering it's prospect, government has given emphasis to introduce this IT based technology in agricultural sector. Application of drone has multifarious aspect . Still it's use is at very much initial stage. Professor Jayshankar Telengana State Agriculture University has done a little bit progress on application of drone technology for pesticide spraying . Vivid research and database is wanting regarding crop health monitoring with the help of multispectral sensors. A multi-disciplinary concerted effort is needed from different research institutions .

Adoption of drone technology in West Bengal is impeded by several constraints. Firstly agriculture sector of this state is dominated by small and fragmented holding. Secondly cost of battery is too high and it requires frequent charging. Thirdly drone is itself also a costly implement.

Problem of small holding can be resolved by establishing cluster approach of the farmers. Farmers Producers Organization may be motivated to introduce drone technology in rural sector.

Government of India has taken some noteworthy initiative to popularizing drone technology. Subsidy maximum upto Rupees Four Lakh has been declared for purchase of drone for individual farmers . Maximum Rs7.50 Lakh will be provided as subsidy to the FPOs under central sector SMAM scheme. FPOs also get advantage of 3% interest subvention, while they are purchasing drone by bank loan through Agriculture Infrastructure Fund. The government has given incentive to the rural business enterprises , FPOs are to set up custom hiring centers, which will lend farmers to use drone at their field at subsidized rate. Apart from spraying pesticides, drome may be used to spray nano-fertilizers as a technology of new horizon.

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APPENDIX

List of pesticides allowed to be sprayed by drone in India (As per F.No.13035/07/2022-PP-I (e-110885) – 18th April 2022

Sr. No.	Chemical Pesticides (Formulation registered)
1.	Abamectin 1.9% EC
2.	Acephate 75% SP
3.	Acephate 95% SG
4.	Acephate 97% DF
5.	Acteamiprid 20% SP
6.	Afidopyropen 50g/l DC
7.	Alphacypermethrin 5% WP
8.	Alphacypermethrin 10% EC
9.	Alphacypermethrin 10% SC
10.	Alphanaphthyl Acetic Acid 4.5% SL
11.	Aureofungin 46.15% SP
12.	Azadirachtin (neemproducts) 0.03% EC
13.	Azadirachtin (neemproducts) 0.1% EC
14.	Azadirachtin (neemproducts) 0.15% EC
15.	Azadirachtin (neemproducts) 0.3% EC
16.	Azadirachtin (neemproducts) 1% EC
17.	Azadirachtin (neemproducts) 5% EC
18.	Azoxystrobin 23% SC
19.	Bendiocarb 8% WP
20.	Benfuracarb 40% EC
21.	Benzpyrimoxam 10% SC
22.	Beta-cyfluthrin 2.45% SC
23.	Bifenazate 22.6% SC
24.	Bifenazate 50% WP
25.	Bifenthrin 8% SC
26.	Bifenthrin 8.8% CS
27.	Bifenthrin 10% EC
28.	Bifenthrin 10% WP
29.	Bitertanol 25% WP
30.	Buprimate 26.7% EC
31.	Buprofezin 25% SC
32.	Captan 50% WP
33.	Captan 50% WG
34.	Captan 75% WS
35.	Captan 75% WP
36.	Carbendazim 46.27% SC
37.	Carbendazim 50% WP
38.	Carbosulfan 25% EC
39.	Carboxin 75% WP
40.	Carpropamid 27.8% SC

41.	Cartap Hydrochloride 50% SP
42.	CartapHydrochloride 75% SG
43.	Chlorantraniliprole 18.5% SC
44.	Chlorantraniliprole 35% WG
45.	Chlorfenapyr 10% SC
46.	Chlorfluazuron 5.4% EC(5% w/v)
47.	Chlormequat Chloride 50% SL
48.	Chlorothalonil 75% WP
49.	Chlorpyriphos 20% EC
50.	Chlorpyriphos 20% CS
51.	Chlorpyriphos 50% EC
52.	Chlorpyriphos75%WG
53.	Chlorpyriphos Methyl 40% EC
54.	Chroma fenozide 80% WP
55.	Clothianidin 50% WG
56.	Copper Hydroxide 46.1% WG
57.	Copper Hydroxide 77% WP
58.	Copper Oxychloride 50% WP
59.	Copper Oxychloride 50% WG
60.	Copper Oxychloride 56% OP
61.	Copper Sulphate 2.62% SC
62.	Cyantraniliprole 10.26% OD
63.	Cyazofamid 34.5% SC
64.	Cyenopyrafen 30.0% w/w SC
65.	Cyflufenamide 5% EW
66.	Cyflumetofen 20% SC
67.	Cyfluthrin 5% EW
68.	Cyfluthrin 10% WP
69.	Cymoxanil 50% WP
70.	Cypermethrin 0.1% Aqueous
71.	Cypermethrin 10% EC
72.	Cypermethrin 25% EC
73.	Cyphenothrin 5% EC
74.	Decamethrin (Deltamethrin) 1.25% ULV
75.	Decamethrin (Deltamethrin) 1.8% EC
76.	Decamethrin (Deltamethrin) 2% EW
77.	Decamethrin (Deltamethrin) 2.8% EC
78.	Decamethrin (Deltamethrin) 11% EC
79.	Diafenthiuron 47.8% SC
80.	Diafenthiuron 50% WP
81.	Dichloropropene and Dichloropropane mixture (DDMixture)*(R)
82.	Dicofol 18.5% EC
83.	Difenoconazole 3% WS
84.	Difenoconazole 25% EC
85.	Diflubenzuron 25% WP
86.	Dimethoate 30% EC

87.	Dimethomorph 50% WP
88.	Dinocap 48% EC
89.	Dinotefuran 20% SG
90.	Dithianon 75% WP
91.	Dodine 40% SC
92.	Dodine 65% WP
93.	Edifenphos 50% EC
94.	Emamectin Benzoate 1.9% EC
95.	Emamectin Benzoate5% SG
96.	Ethephon 39% SL
97.	Ethion 50% EC
98.	Ethofenprox (Etofenprox)10% EC
99.	Etoxazole10% SC
100.	Fenazaquin10% EC
101.	Fenazaquin 18.3% SC
102.	Fenitrothion R40% WP
103.	Fenitrothion R 20% OL(banned in agriculture use except for locust in Scheduled dessert area and public health)
104.	Fenobucarb (BPMC)50% EC
105.	Fenpropathrin 10% EC
106.	Fenpropathrin 30% EC
107.	Fenpyroximate 5% EC
108.	Fenpyroximate 5% SC
109.	Fenvalerate 0.4% DP
110.	Fenvalerate 20% EC
111.	Fipronil 0.6% WG
112.	Fipronil 2.92% EC
113.	Fipronil 5% SC
114.	Fipronil 18.87% SC
115.	Fipronil 80% WG
116.	Flonicamide 50% WG
117.	Flubendiamide 20% WG
118.	Flubendiamide 39.35% SC
119.	Flufenoxuron 10% DC
120.	Flumite 20% SC
121.	Fluopyram 34.48% SC
122.	Flupyradiflurone17.9% w/w SL
123.	Flupyrimin 10% SC
124.	Flusilazole 40% EC
125.	Fluvalinate 25% EC
126.	Fluxametamide 10% EC
127.	Forchlorfenuron (CPPU) 0.1%L
128.	Forchlorfenuron 0.12% EC
129.	Fosetyl-Al 80% WP
130.	Gibberellic Acid 0.001% L
131.	Gibberellic Acid 0.186% SP

132.	GibberellicAcid 0.45% SL
133.	GibberellicAcid 40% WSG
134.	Hexaconazole 2% SC
135.	Hexaconazole 5% SC
136.	Hexaconazole 5% EC
137.	Hexaconazole 75% WG
138.	Hexythiazox 5.45% EC
139.	Hydrogen Cyanamide 49% AS
140.	Hydrogen Cyanamide 50% SL
141.	Imidacloprid 17.1% SL
142.	Imidacloprid 17.8% SL
143.	Imidacloprid 30.5% SC
144.	Imidacloprid 70% WG
145.	Indoxacarb 14.5% SC
146.	Indoxacarb15.8% EC
147.	Iprobenfos(Kitazin) 48% EC
148.	Iprodione 50% WP
149.	Isoprothiolane 40% EC
150.	Kasugamycin 3% SL
151.	Kresoxim-methyl 44.3% (500g/l) SC
152.	Lambda-cyhalothrin 2.43% CS
153.	Lambda-cyhalothrin 2.5% EC
154.	Lambda-cyhalothrin 4.9% CS
155.	Lambda-cyhalothrin 5% EC
156.	Lambda-cyhalothrin 9.7% CS
157.	Lambda-cyhalothrin 10% WP
158.	Lambda-cyhalothrin 22.8% CS
159.	LimeSulphur 22% SC
160.	Lufenuron 5.4% EC
161.	Malathion 5% DP
162.	Malathion 25% WP
163.	Malathion 50% EC
164.	Malathion 96% ULV
165.	Mancozeb 35% SC
166.	Mancozeb 75% WG
167.	Mancozeb 75% WP
168.	Mandipropamid 23.4% SC
169.	MepiquatChloride 5% AS
170.	Meptyl dinocap 35.7% EC
171.	Metaflumizone 22% SC
172.	Metalaxyl 35% WS
173.	Metalaxyl–M31.8%ES
174.	Methoxyfenazide21.8% SC
175.	Metiram 70% WG
176.	Metrafenone 500g/l SC
177.	Milbemectin 1% EC

178.	Monocrotophos R15% w/w SG
179.	Monocrotophos R 36% SL
180.	Myclobutanil 10% WP
181.	Novaluron 10% EC
182.	Novaluron 8.8% SC
183.	Oxathiapipron 10.1% OD
184.	Oxycarboxin 20% EC
185.	Oxydemeton-methyl 25% EC
186.	Paclobutrazol 40% SC
187.	Paclobutrazol 23%SC
188.	Penconazole10% EC
189.	Pencycuron 22.9% SC
190.	Permethrin 5% SG
191.	Permethrin 25% EC
192.	Phenthoate50%EC
193.	Phosalone 35% EC
194.	Picoxystrobin 22.52% SC
195.	Polyoxin D Zinc salt 5% SC
196.	Prochloraz 39.6% EC
197.	Profenophos 50% EC
198.	Prohexadionecalcium 10% WG
199.	Propergite 57% EC
200.	Propetamphos 20% EC
201.	Propiconazole 25% EC
202.	Propineb 70% WP
203.	Pymetrozine 50% WG
204.	Pyraclostrobin 100g/l CS
205.	Pyraclostrobin 20% WG
206.	Pyrethrum 2.0% EC
207.	Pyridaben 20% WP
208.	Pyridalyl 10% EC
209.	Pyriproxifen 10% EC
210.	Quinalphos 20% AF
211.	Quinalphos 25% EC
212.	Sodium para nitrophenolate 0.3% SL
213.	Sodium para nitrophenolate 1.8% SL
214.	Spinetoram 11.7% SC
215.	Spinosad 2.5% SC
216.	Spinosad 45% SC
217.	Spiromesifen 22.9% SC
218.	Spirotetramat 15.31% OD
219.	Sulfoxaflor 21.8% SC
220.	Sulphur 40% SC
221.	Sulphur 52% Flowable
222.	Sulphur 55.16% SC (800gm/L)
223.	Sulphur 80% WG

224.	Sulphur 80% WP
225.	Tebuconazole 2% DS
226.	Tebuconazole 25% WG
227.	Tebuconazole 25.9% EC
228.	Tebuconazole 38.39% SC
229.	Tetraconazole 11.6% w/w (12.5%w/v)SL
230.	Tetraconazole 3.8% EW
231.	Tetraniliprole 18.18% SC
232.	Thiacloprid 21.7% SC
233.	Thifluzamide 24% SC
234.	Thiocyclam hydrogen oxalate 50% SP
235.	Thiodicarb75% WP
236.	Thiomethoxam 25% WG
237.	Thiomethoxam 70% WS
238.	Thiomethoxam 75% SG
239.	Thiophanate-methyl 70% WG
240.	Thiophanate-methyl 70% WP
241.	Thiram 75% WS
242.	Tolfenpyrad 15% EC
243.	Triadimefon 25% WP
244.	Tricontanol 0.05% EC
245.	Tricontanol 0.1% EW
246.	Tricyclazole 70% WG
247.	Tricyclazole 75% WP
248.	Triflumezopyrim 10% SC
249.	Triflumizole 42.14% SC
250.	Validamycin 3% L
251.	Zineb75 % WP
252.	Ziram 27% SC
253.	Ziram 80% WP

S. No.	Biopesticides (Formulations Registered)
254.	Ampelomyces quisqualis 2.0% A.S.(IPL/AQ/06)
255.	Ampelomyces quisqualis 2.0% WP (Aq-1MTCC-5683)
256.	Bacillus subtilis1.0% WP (CPBT15TCC-5527)
257.	Bacillus subtilis 1.5% LF (Bs-1,MTCC25072)
258.	Bacillus thuringiensis var.galleriae 1.3% FC
259.	Bacillus thuringiensis var.sphaericus 1.3% FC
260.	Bacillus thuringiensis kurstaki 0.5%WP Serotype 3a, 3b, 3c (DORBt-1, B-01118)
261.	Bacillus thuringiensis kurstaki 5% WP
262.	Bacillus thuringiensis kurstaki 2.5% AS Serotype 3a, 3b, 3c
263.	Bacillus thuringiensis kurstaki 3.5% ES Serotype 3a,3b,3c
264.	Bacillus thuringiensis var. israelensis 0.5% AS
265.	Bacillus subtilis 1.5% A.S. (BIL, BS-168)
266.	Bacillus subtilis 1.5% A.S. (KTSBMTCC5786)

267.	Bacillus subtilis 1.15% A.S
268.	Bacillus subtilis 2.0% A.S.(IPL/BS/09,MTCC-5728)
269.	Bacillus thuringiensis var.israelensis 5% AS, B-17 serotype H-14 (VCRC-B-17,MTCC-5596)
270.	Bacillusthuringiensisvar.israelensis0.5%WP
271.	Bacillus thuringiensis var.israelensis 5% WP
272.	Bacillus thuringiensis var.israelensis 12% AS
273.	Bacillus thuringiensis var.4 rustaki,serotype H-39, 3B, starin Z52
274.	Beauveria basiana 1.15% WP (Bb-1, MTCCNo.5171)
275.	Beauveria basiana 1.15% WP (BB-5372)
276.	Beauveria basiana 1.15% WP (ICAR-Umaim, NAIMCC-03045)
277.	Beauveria basiana 1.50% LF(Bb-1, MTCCNo.5171)
278.	Beauveria bassiana 1.00% WP (NBRI-9947)
279.	Beauveria bassiana 1.00% WP (SVBPU/CSP/BB-10/ITCC-7520)
280.	Beauveria bassiana 2.0%A.S.(IPL/BB/MI/01, 6897)
281.	Beauveria bassiana 5.0% SC (NBAI, ITCC7102)
282.	Beauveria bassiana 5.0% WP (IARI,7353)
283.	Beauveria bassiana 1.0% W.P.(SVBPU/CSP/Bb-10,ITCC-7520)
284.	Beauveria bassiana 1.15% WP(BB-ICAR-RJP,MCC-1022)
285.	Hirsutellathompsonii 2.0% A.S.(IPL/HT/01)
286.	Metarhizium anisopliae 2.0% SC (KSCL/Ma-59 ITCC-7058)
287.	Metarhizium anisopliae 1.15% WP (Ma-1MTCC5173)
288.	Metarhizium anisopliae 2.0% A.S (IPL/KC/44 ITCC-6895)
289.	Metarhizium anisopliae 1.15% WP (Ma-1MTCC-5173)
290.	Metarhizium anisopliae 1.50% LF (Ma-1MTCC5173)
291.	Metarhizium anisopliae 5.0% SC (NBAII,7103)
292.	Metarhizium anisopliae 1.00% WP (CPB/PSP-T26MTCC5699)
293.	Metarhizium anisopliae 1.00% WP (IPL/KC/44ITCC-6895)
294.	Metarhizium anisopliae 1.15% WP (NAIMCC-F-03037)
295.	NPV of Helicoverpa armigera 0.43% AS
296.	NPV of Helicoverpa armigera 0.5% AS
297.	NPV of Helicoverpa armigera 1% WP
298.	NPV of Spodoptera litura 2.0% AS
299.	NPVof Spodoptera litura 0.5% AS
300.	Paecilomyces lilacinus 1.0% S.P.(IIHR-PL-2ITCC-6887)
301.	Paecilomyces lilacinus 1.0% W.P.(IIHR-PL-2 ITCC-6887)
302.	Paecilomyces lilacinus 1.5% LF
303.	Pseudomonas fluorescens 0.5% W.P. (TNAU PF-1 ITCC BE-0005)
304.	Pseudomonas fluorescens 1.75% WP (PF-1 MTCC No.5671)
305.	Pseudomonas flourescens 1.5% LF (PF-1, MTCC No.5671)
306.	Pseudomonas fluorescens 0.5% W.P.(BIL-331 MTCC-5866)
307.	Pseudomonas fluorescens 1.0% W.P.(IPL/PS-01, MTCC-5727)
308.	Pseudomonas fluorescens 1.0% W.P.(IIHR-PF-2, ITCCB-0034)
309.	Pseudomonas fluorescens 1.5% A.S. (AS-AAIF,MCC2539)
310.	Pseudomonas fluorescens 1.5% WP
311.	Pseudomonas fluorescens 2.0% A.S. (IPL/PS-01)

312.	Trichoderma harzianum 1.0% WP (Th3, ITCC-5593)
313.	Trichoderma ressei 3.0% WP (CSR-T-3, NAIMCC-SF-0030)
314.	Trichoderma viride 2% W.P. (BHU, NAIMCC-F-02976)
315.	Trichoderma viride 0.50% W.P.
316.	Trichoderma viride 1.0% AS (TV-AAU-RJP,MCC-1013)
317.	Trichoderma viride 1.0% W.P. (Tv-1,ITCC-6914)
318.	Trichoderma viride 1.00% W.P. (BIL-198)
319.	Trichoderma viride 1.00% W.P.(IPL/VT/101)
320.	Trichoderma viride 1.00% W.P .(KAU,MTCC-5694)
321.	Trichoderma viride 1.00% W.P. (T-14)
322.	Trichoderma viride 1.5% LF (Tv-1, MTCC-5170)
323.	Trichoderma viride 5% LF(NAIM-F-03034)
324.	Trichoderma viride1.50%W.P.(IIHR-Tv-5,ITCC-6889)
325.	Trichoderma viride 5% WP
326.	Trichoderma harzianum 5.0% WP
327.	Trichoderma harzianum 5.0% SC(ITCC-7111)
328.	Trichoderma harzianum 0.5% WS (T-39)
329.	Trichoderma harzianum 1.0% W.P. (IIHR-Th-2, ITCC-6888)
330.	Trichoderma harzianum 2.0% A.S.(IPL/VT/102 6893)
331.	Trichoderma harzianum 2.0% WP (NBRI-1055)
332.	Verticilium lecanii 1.50% LF (Vl-1,MTCCNo.5172)
333.	Verticillium chlamydosporium 1.0% W.P.(IIHR-VC-3,ITCC6898)
334.	Verticillium lecanii 2.0% A.S.(IPL/VL/05)
335.	Verticillium lecanii 5.0% SC (NBAII2638)
336.	Verticillium lecanii 1.15% WP (AAI,NAIMCC-F-03007)
337.	Verticillium lecanii 1.15% WP (AS-MEGH-VL, MCC-1028)
338.	Verticillium lecanii 1.15% WP (Vl-1,MTCCNo.5172)

Sr No.	Combination Pesticide (Insecticides) (Formultions Registered)
1.	Acephate 25% + Fenvalerate 3% EC
2.	Acephate 50% + Bifenthrin 10% WDG
3.	Acephate 50% + Fipronil 5% WDG
4.	Acephate 50% + Imidacloprid 1.8% SP
5.	Acetamiprid 0.4% + Chlorpyriphos 20% EC
6.	Acetamiprid 1.1% + Cypermethrin 5.5% EC
7.	Betacyfluthrin 8.49% + Imidacloprid 19.81% OD
8.	Bifenthrin 3%+ Chlorpyriphos 30% EC
9.	Buprofezin 20% + Acetamiprid 2% WP
10.	Buprofezin 15%+ Acephate 35% WP
11.	Buprofezin 20% + Acephate 50% WP
12.	Buprofezin 20% + Acetamiprid 2% WP
13.	Buprofezin 22.0% +Fipronil 3.0% SC
14.	Buprofezin 23.1% + Fipronil 3.85% SC
15.	Buprofezin 9.0% + Acephate 24.0% WP
16.	Cartaphydrochloride 50%+ Buprofezin 10% WP
17.	Chlorantraniliprole 4.3% + Abamectin 1.7% SC

18.	Chlorantraniliprole 8.8% +Thiamethoxam 17.5% SC
19.	Chlorantraniliprole 9.3% +Lambdacyhalothrin 4.6% ZC
20.	Chloropyriphos 16% + Alphacypermethrin 1% EC
21.	Chlorpyriphos 50% +Cypermethrin 5% WG
22.	Chlorpyriphos 50% + Cypermethrin 5% EC
23.	Cyclanilide 2.10% + MepiquatChloride 8.40% SC
24.	Cypermethrin 10% +Indoxacarb10% SC
25.	Cypermethrin 3% + Quinalphos 20% EC
26.	Deltamethrin 0.72% + Buprofezin 5.65% EC
27.	Diafenthiuron 30% + Pyriproxifen 8% SE
28.	Difenthiuron 47.0% + Bifenthrin 9.4% SC
29.	Dinotefuran 15% + Pymetrozine 45% WG
30.	Dinotefuran15% + Pymetrozine 45% WG
31.	Dinotefuran 4% +Acephate 50% SG
32.	Emamectin benzoate 1.5% + Profenofos 35% WDG
33.	Emamectin Benzoate 1.5% + Fipronil3.5% SC
34.	Emamectin Benzoate 5% + Lufenuron 40% WG
35.	Ethion 40% + Cypermethrin 5% EC
36.	Ethiprole 40% + Imidacloprid 40% WG
37.	Fenazaquin10% + Bifenthrin 4% EC
38.	Fenobucarb 20%+ Buprofezin 5% SE
39.	Fipronil 40% + Imidacloprid 40% WG
40.	Fipronil 40% +Imidacloprid 40% WG
41.	Fipronil 5% + Buprofezin 20%
42.	Fipronil 7% +Hexythiazox 2% w/w SC
43.	Fipronil 4%+ Acetamiprid 4% w/w SC
44.	Fipronil 4% + Thiamethoxam 4% w/w SC
45.	Flubendiamide 19.92% +Thiacloprid 19.92% SC
46.	Flubendiamide 3.50% + Hexaconazole 5% WG
47.	Flubendiamide 4%+ Buprofezin 20% SC
48.	Flubendiamide 7.5% +Kresoxim methyl 37.5% SC
49.	Flubendiamide 8.33% + Deltamethrin 5.56% SC
50.	Hexythiazox 3.5+Diafenthiuron 42% WDG
51.	Imidacloprid 21% + Beta-cyfluthrin 10.5% SC
52.	Imidacloprid 6.0% +Lambdacyhalothrin 4.0% SL
53.	Indoxacarb 14.5% +Acetamiprid 7.7% SC
54.	Indoxacarb 5% +Fipronil 5% SC
55.	Isoprothiolane 28% + Fipronil 5% EC
56.	Novaluron 5.25% + Emamectin benzoate 0.9% w/w SC
57.	Novaluron 5.25% +Indoxacarb 4.5% SC
58.	Phenthoate 45% + Cypermethrin 6% EC
59.	Profenofos 40% + Cypermethrin 4% EC
60.	Profenofos 40% +Fenpyroximate 2.50% EC
61.	Propargite 42% + Hexythiazox 2% EC
62.	Propargite 50%+ Bifenthrin 5% SE
63.	Pyriproxyfen 10% + Bifenthrin 10% EC

64.	Pyriproxyfen 5% + Fenpropathrin 15% EC
65.	Pyriproxyfen 5.0% + Diafenthiuron 25% SE
66.	Spirotetramat 11.01% + Imidacloprid 11.01% SC
67.	Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC

Sr. No.	Fungicides (Formulations Registered)
1.	Ametoctradin 27% +Dimethomorph 20.27% SC
2.	Azoxysrobin 120g/l + Tebuconazole 240 g/l SC
3.	Azoxystrobin 11.0% +Tebuconazole 18.3% SC
4.	Azoxystrobin 12.5% + Tebuconazole 12.5% SC
5.	Azoxystrobin 12.5% +Tebuconazole 12.5% SC
6.	Azoxystrobin 18.2% + Cyproconazole 7.3% SC
7.	Azoxystrobin 18.2% +Difenoconazole 11.4% SC
8.	Azoxystrobin 4.8% + Chlorothalonil 40.0% SC
9.	Azoxystrobin 7.1% + Propiconazole 11.9% SE
10.	Azoxystrobin 8.3% + Mancozeb 66.7% WG
11.	Azoxystrobin 11.5% +Mancozeb 30.0% WP
12.	Azoxystrobin 16.7% +Tricyclazole 33.3% SC
13.	Benalaxyl 8.0%+ Mancozeb65% WP
14.	Benalaxyl-M 4.0% + Mancozeb 65.0% WP
15.	Boscalid 25.2% + Pyraclostrobin 12.8% WG
16.	Captan 70% +Hexaconazole 5% WP
17.	Carbendazim 12% + Mancozeb 63% WP
18.	Carbendazim 12% + Mancozeb 63% WS
19.	Carbendazim 25%+ Flusilazole 12.5% SE
20.	Carbendazim 25% + Mancozeb 50% WS
21.	Carfentrazone Ethyl 20% +Sulfosulfuron 25% WG
22.	Chlorothalonil 40% + Difenconazole 4% w/w SC
23.	Copper Sulphate 47.15% +Mancozeb 30% WDG
24.	Cymoxanil 8% +Mancozeb 64% WP
25.	Dimethomorph 12%+ Pyraclostrobin 6.7% WG
26.	Famoxadone 16.6% + Cymoxanil 22.1% SC
27.	Fenamidone 10% + Mancozeb 50% WDG
28.	Fenamidone 4.44% + Fosetyl-Al 66.66% WDG
29.	Fluopicolide 5.56% + Propamocarb hydrochloride 55.6% SC
30.	Fluopyram 17.7% + Tebuconazole 17.7% SC
31.	Fluxapyroxad167 g/L+ Pyraclostrobin 333g/l SC
32.	Fluxapyroxad 250 g/l + Pyraclostrobin 250 g/l SC
33.	Fluxapyroxad 62.5 g/l + Epoxiconazole 62.5g/l EC
34.	Fluxapyroxad 75 g/l + Difenconazole 50 g/l SC
35.	Hexaconazole 4%+ Carbendazim16% w/w SC
36.	Hexaconazole 4% +Zineb 68% WP
37.	Hexaconazole 5% + Validamycin 2.5% SC
38.	Improvalicarb 5.5% +Propineb 61.25% WP
39.	Iprodion 25% + Carbendazim 25% WP
40.	Kasugamycin 5% +Copper Oxychloride 45% WP

41.	Kresoxim methyl 15% + chlorothalonil 56% WG
42.	Kresoxim methyl 18% + Mancozeb 54% w/w WP
43.	Kresoxim methyl 40% + Hexaconazole 8% w/w WG
44.	Mancozeb 40% +Azoxytrobin7.0% w/w OS
45.	Mancozeb 50%+ Thiophanate methyl 25% WG
46.	Mandipropamid 5.0% +Mancozeb 60.0% WG
47.	Metalaxyl–M 3.3% + Chlorothalonil 33.1% SC
48.	Metalaxyl-M 8%+ Mancozeb 64% WP
49.	Metalaxyl-M 4% + Mancozeb 64% WP
50.	Metiram 44% + Dimethomorph 9% WG
51.	Metiram 55% + Pyraclostrobin 5% WG
52.	Picoxystrobin 6.78%+ Tricyclazole 20.33% SC
53.	Picoxystrobin 7.05% +Propiconazole 11.7% SC
54.	Prochloraz 24.4% + Tebuconazole 12.1% EW
55.	Prochloraz 34.8% + Propiconazole 7.8% EC
56.	Prochloraz 5.7% + Tebuconazole 1.4% ES
57.	Prochloraz 23.5% +Tricyclazole 20% SE
58.	Propiconazole 10.7% + Tricyclazole 34.2% SE
59.	Propiconazole 13.9% + Difenoconazole 13.9% EC
60.	Propineb 54.2%+ Tricyclazole 15.0% WP
61.	Pyroclostrobin 133g/l + Epoxiconazole 50g/l (w/v) SE
62.	Streptomycin + Tetracycline (90+10)
63.	Tebuconazole 10% + Sulphur 65% WG
64.	Tebuconazole 15% + Zineb 57%W DG
65.	Tebuconazole 50% + Trifloxystrobin 25% WG
66.	Tebuconazole 6.7% + Captan 26.9% SC
67.	Triafamone 20% + Ethoxysulfuron 10% WG
68.	Tricyclazole 18% + Mancozeb 62% WP
69.	Tricyclazole18.0 + Tebuconazole 14.4% SC
70.	Tricyclazole 20.4%+ Azoxystrobin 6.8% SC
71.	Tricyclazole 45% + Hexaconazole 10% WG
72.	Flubendiamide 3.5% + Hexaconazole 5% WG