DJI AGRICULTURE

AGRICULTURAL DRONE INDUSTRY INSIGHT REPORT

(2023/2024)

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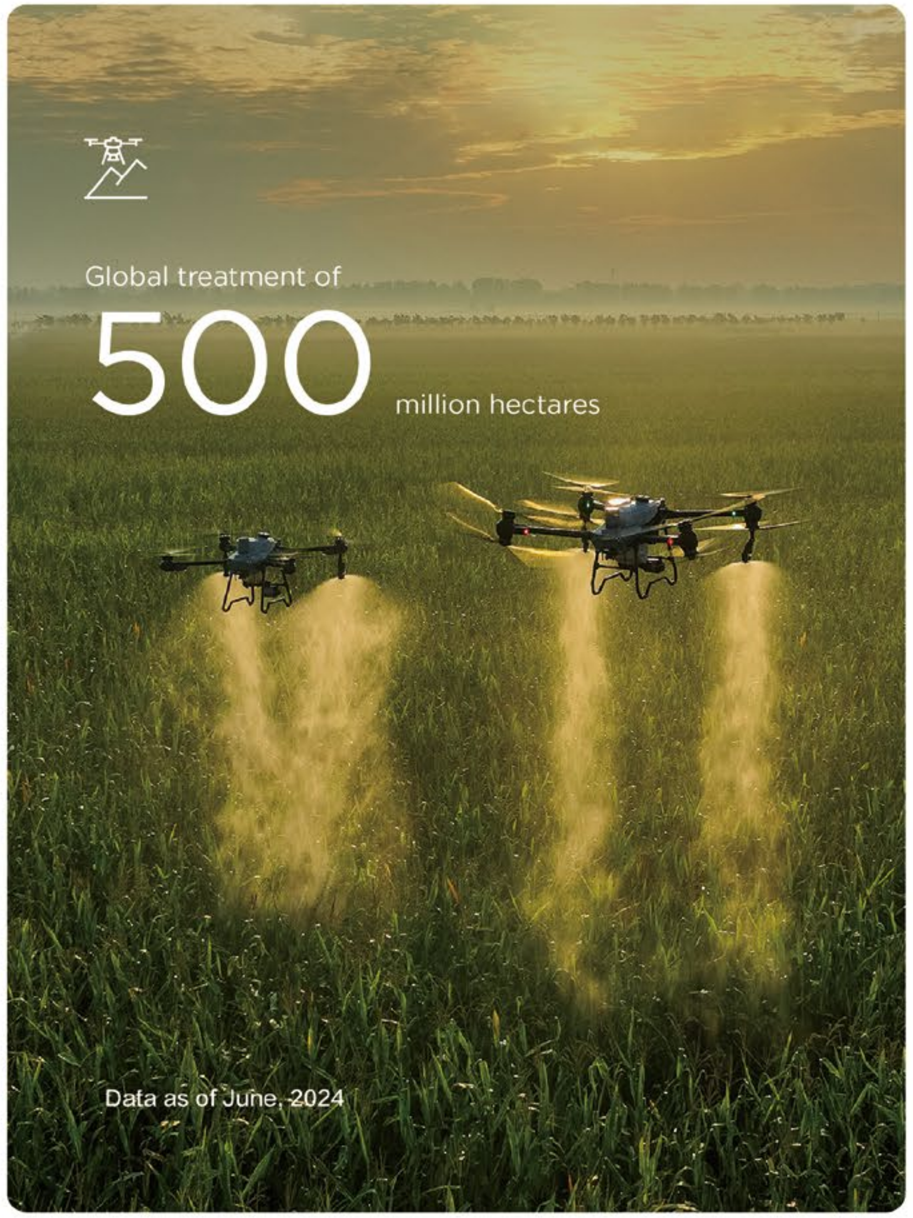
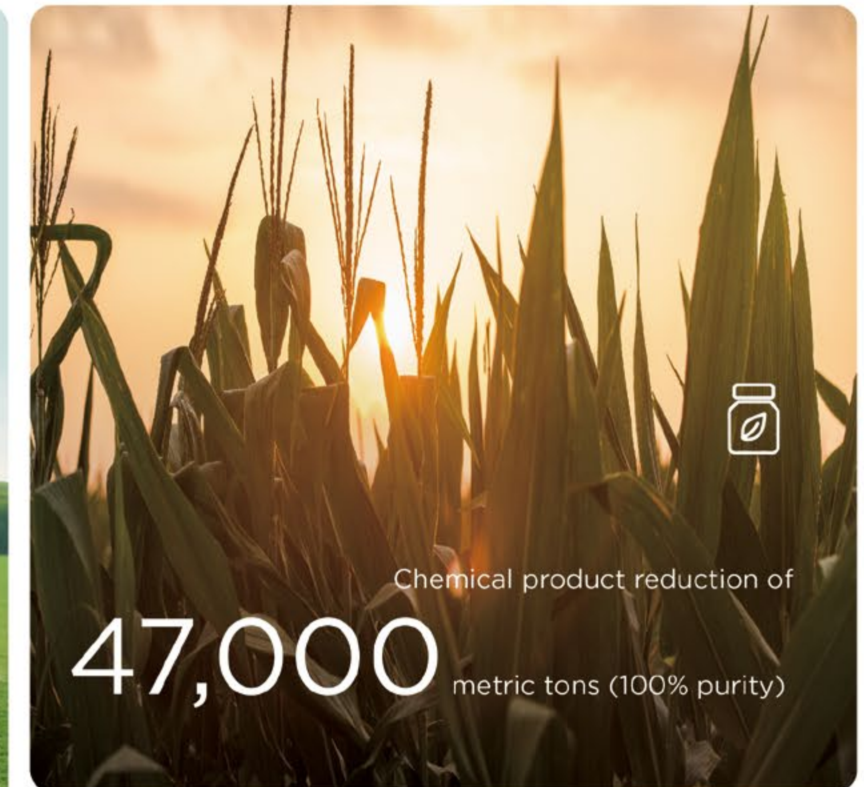
Introduction

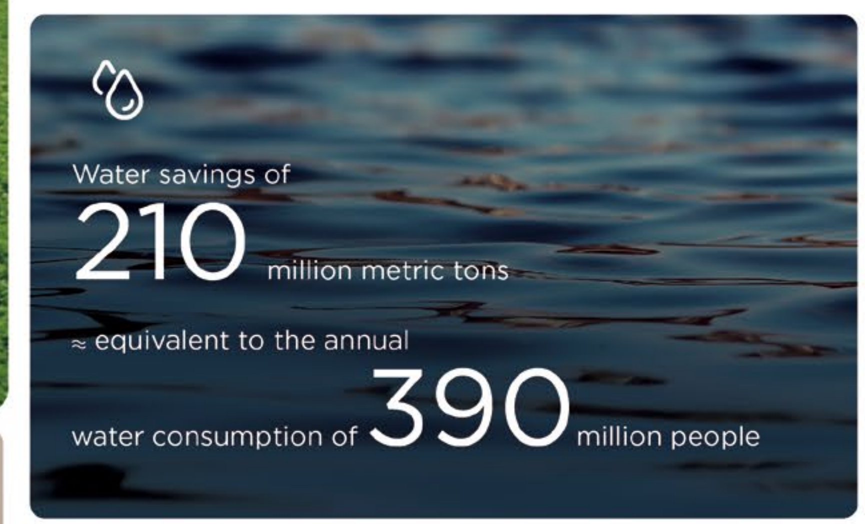
Our mission to promote sustainable agriculture through technology has led to the rise of agricultural drones as efficient production tools, offering innovative solutions to various challenges such as food production, soil health, and environmental protection. By the end of 2023, over 300,000 agricultural drones were in use globally, spanning more than 100 countries and regions. As of June 2024, these drones have been used to treat over 500 million hectares globally, with 6,000 instructors and 300,000 pilots trained to operate them.

By treating over 500 million hectares, agriculture drones have yielded cumulative savings of 210 million metric tons of water—equivalent to the annual water consumption of 390 million people. Additionally, the use of agricultural drones has significantly reduced the use of chemical products by 47,000 metric tons (100% purity) and cut carbon emissions by 25.72 million metric tons—equivalent to the annual carbon sequestration of 1.2 billion trees.

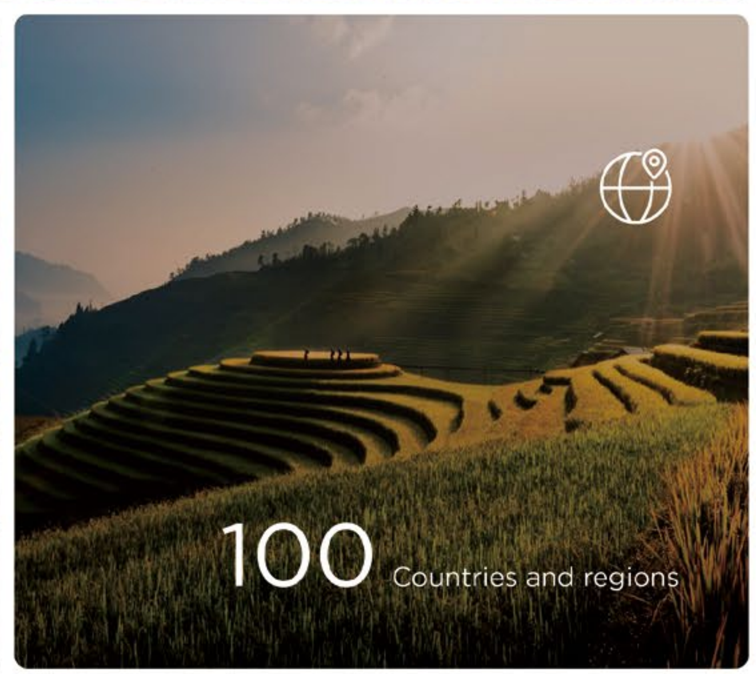

Global treatment of
500 million hectares
Data as of June, 2024


Coverage of
1/3
of China's farmland


Chemical product reduction of
47,000 metric tons (100% purity)


Water savings of
210 million metric tons
≈ equivalent to the annual
water consumption of 390 million people


Training of
6,000 instructors
300,000 pilots


100 Countries and regions


CO2
Carbon emission reductions
of 25.72 million metric tons
≈ equivalent to the carbon sequestration
of 1.2 billion trees

Events in 2023

January

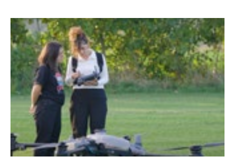
Agriculture drones were used for precision herbicide spraying in the US, resulting in a yield increase of $17 per acre.

February

DJI Agriculture launched a 10-hectare demonstration orchard for navel oranges, challenging a single farmer to manage the operations throughout the year using agricultural drones in complex hilly terrain.

March

On International Women's Day, statistics showed that more than 7,000 women had joined the agricultural drone industry.



April

DJI Agriculture initiated drifting tests for the T50 and T25 models in China.

May

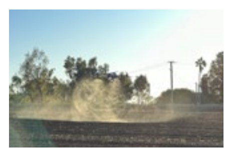
DJI Agriculture participated in the OECD Agricultural Drone Regulation Seminar, discussing technological innovation and management of agricultural drones across multiple countries.

June

The T20P drone was released in the Americas, officially introduced and available for sale.

July

DJI Agriculture conducted drifting tests in Australia.



August

DJI Agriculture supported the FAO in hosting the "Asia-Pacific Agricultural Drone Application" event.

September

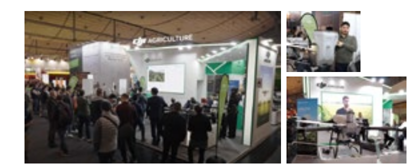
DJI Agriculture helped boost small-scale sugarcane farmers' yields and incomes in South Africa, achieving a maximum sugar yield increase of 1.78 tons per hectare.

October

DJI Agriculture supported the FAO World Food Day, advocating for water resource protection and food security.

November

DJI Agriculture introduced the Agras T50, Agras T30, and Mavic 3M at AGRITECHNICA, one of the world's largest agricultural machinery exhibitions in Germany.



December

The Agras T25 was released and made available for sale in Japan and South Korea.

Global Policy Trends

From 2023 to 2024, the global adoption of agricultural drones by farmers and agricultural practitioners increased significantly. This period also saw governments in various countries gaining a deeper understanding of the technology. Many nations have since liberalized their regulations, classifying agricultural drones as low-risk aircraft and providing guidance for their use in agricultural spraying, akin to the regulations for ground-based equipment.

Brazilian Regulations Support Agricultural Drones

1. ANAC Amends Regulations for Agricultural Drones

In April 2023, ANAC[1] issued a new amendment of drone regulation, eliminating the mandatory airworthiness requirements for agricultural drones and replacing them with voluntary compliance. Local operators only need to register their agricultural drones and obtain a license. This new regulation underwent extensive discussions by local authorities. During legislative discussions, the regulators highlighted the importance of Brazilian agriculture industry and the differing outcomes that the management of agricultural drones under various drone regulations could bring. This decision ultimately brought tremendous convenience to Brazilian farmers, leading to more farmers choosing drone operations.


RESOLUÇÃO Nº 710, DE 31 DE MARÇO DE 2023.

Aprova a Emenda nº 03 ao RBAC-E nº 94.

A DIRETORIA COLEGIADA DA AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL, no exercício da competência que lhe foi outorgada pelo art. 11, inciso V, da Lei nº 11.182, de 27 de setembro de 2005, tendo em vista o disposto no arts 5º, 8º, incisos X, XVI, XVII, XVIII e XLVI, da mencionada Lei, e considerando o que consta do Processo nº 00066.004929/2021-86, deliberado e aprovado na 5ª Reunião Deliberativa, realizada em 28 de março de 2023,

RESOLVE:

Art. 1º Aprovar a Emenda nº 03 ao Regulamento Brasileiro da Aviação Civil Especial - RBAC-E nº 94, intitulado "Requisitos gerais para aeronaves não tripuladas de uso civil", consistente nas seguintes alterações:

"**E94.5** ....

....

(b) Os RPAS durante a aplicação de agrotóxicos e afins, adjuvantes, fertilizantes, inoculantes, corretivos e sementes sobre áreas desabitadas são classificados para fins deste regulamento como Classe 3, independentemente do peso máximo de decolagem da RPA, desde que operando VLOS ou EVLOS e até 400 pés AGL.

(1) Adicionalmente, os operadores e os fabricantes devem informar à ANAC qualquer caso de possível saída da área de voo autorizado.

(2) Para tais operações aplica-se o RBAC-E 94.701(a)(2) independentemente do peso da RPA.

(3) Para tais operações não se aplica o RBAC-E 94.103(d) e o RBAC-E 94.701(a)(2)(ii)." (NR)

Parágrafo único. A Emenda de que trata este artigo encontra-se disponível no Boletim de Pessoal e Serviço - BPS desta Agência (endereço eletrônico https://www.anac.gov.br/assuntos/legislacao/legislacao-1/boletim-de-pessoal) e na página "Legislação" (endereço eletrônico https://www.anac.gov.br/assuntos/legislacao), na rede mundial de computadores.

Art. 2º Esta Resolução entra em vigor em 2 de maio de 2023.

JULIANO ALCANTARA NOMAN
Diretor-Presidente

Publicado no Diário Oficial da União de 3 de abril de 2023, Seção 1, página 72.

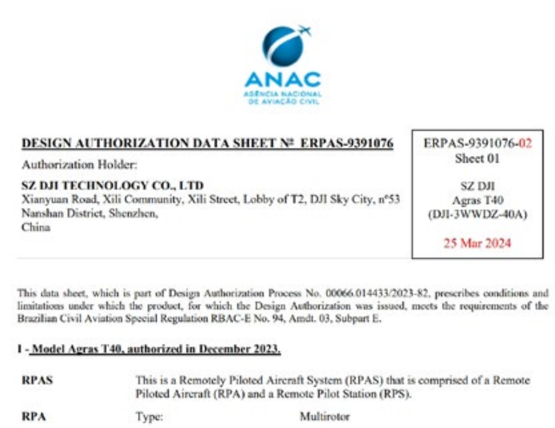
ANAC's Amendment

Before 2023, Brazil's drone regulation required mandatory airworthiness for drones weighing more than 25 kg[2]. This management method may take 2-3 years for each model from the beginning to the completion of the process. Since 2022, DJI has applied to ANAC for airworthiness for three models, T30, T40, and T20P. In December 2023, these models obtained airworthiness, and the Brazilian Civil Aviation Administration held an online certification ceremony. This is the first time that DJI's drone products have obtained airworthiness certificates overseas, which means that DJI's agricultural drone model design and production have been officially recognized in Brazil.[3]


Agência Nacional de Aviação Civil (Anac) — O que você procura?

DJI	Agras T20P	ERPAS- 9474851-03	25/03/2024	Classe 3	Operação VLOS ou EVLOS
DJI	Agras T30	ERPAS- 9425610-02	25/03/2024	Classe 3	Operação VLOS ou EVLOS
DJI	Agras T40	ERPAS- 9391076-02	25/03/2024	Classe 3	Operação VLOS ou EVLOS

Airworthiness Certificate for T30/T40/T20p


ANAC
AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL

DESIGN AUTHORIZATION DATA SHEET Nº ERPAS-9391076

Authorization Holder:

SZ DJI TECHNOLOGY CO., LTD
Xianyuan Road, Xili Community, Xili Street, Lobby of T2, DJI Sky City, nº53
Nanshan District, Shenzhen,
China

ERPAS-9391076-02
Sheet 01
SZ DJI
Agras T40
(DJI-3WWDZ-40A)
25 Mar 2024

This data sheet, which is part of Design Authorization Process No. 00066.014433/2023-82, prescribes conditions and limitations under which the product, for which the Design Authorization was issued, meets the requirements of the Brazilian Civil Aviation Special Regulation RBAC-E No. 94, Amdt. 03, Subpart E.

I - Model Agras T40, authorized in December 2023.

RPAS	This is a Remotely Piloted Aircraft System (RPAS) that is comprised of a Remote Piloted Aircraft (RPA) and a Remote Pilot Station (RPS).	
RPA	Type:	Multirotor

Airworthiness Certificate for T40

1. Agência Nacional de Aviação Civil (ANAC): https://www.gov.br/anac/en
2. Drone categories in Brazil: https://www.gov.br/anac/en/topics/drones/classification-of-drones
3. See: https://www.gov.br/anac/pt-br/assuntos/drones/projetos-autorizados

2. Pesticide Use in Brazil

There are lots of traditional aircrafts in agriculture use in Brazil, such as helicopters and small fixed-wing aircrafts. Chemical products registered locally that indicate on the label applied by "aircraft" can also be used for agricultural drones.

Mapa[4] presented at the Drone Show 2024[5], in São Paulo, updates to Brazilian standards for the use of drones in agriculture with a lecture by the head of Mapa's Agricultural Aviation Division, Uéllen Colatto, on Tuesday, at Expo Center Norte.

In the presentation, the head of the Agricultural Aviation Division addressed Ordinance 298, published in September 2021, and the challenges for its application. The document establishes rules for the operation of remotely piloted aircraft intended for the application of pesticides and similar products, adjuvants, fertilizers, inoculants, corrective agents and seeds. Inspection of agricultural aviation is carried out by federal agricultural tax auditors and technical assistants from Mapa.

4. Ministry of Agriculture, Livestock and Food Supply: https://www.abc.gov.br/training/informacoes/InstituicaoMAPA_en.aspx
5. See: https://www.gov.br/agricultura/pt-br/assuntos/noticias/mapa-apresenta-normas-sobre-uso-de-drones-na-agricultura-na-drone-show

Licenses and Exemptions in North America

1. United States

According to the FAA's requirements, if agricultural drones are used for spraying economic poison and fall within the part 137, they can apply for exemptions according to 44807. From 2023 to 2024, DJI users in the United States have successively obtained operating exemptions for T30 and T40.

In February 2024, the FAA released a list of exempted models. Local users who have obtained operating exemptions and have indicated "all exempted models can be used" on their exemption authorization letters can directly use the models on the list. DJI's agricultural drones weighing more than 25 kg are all on the exemption list.

List of Approved UAS under Section 44807

Note: this list is for reference purposes only, and does not grant any Operator with authorization to operate any UAS on this list. Only Operators holding a valid grant of exemption under Section 44807 for specific UAS approved for use on their exemption may conduct operations with that UAS in compliance with the Conditions and Limitations of their Exemption.

Make	Model	Approved Maximum Take-Off Weight (MTOW), incl. Payload	Approved For Part 137 Agricultural Operations
DJI	Agras T16	92.6 lbs.	Approved
DJI	Agras T20P	127.86 lbs.	Approved
DJI	Agras T20	104.5 lbs.	Approved
DJI	Agras T30	171.96 lbs.	Approved
DJI	Agras T40	222.66 lbs.	Approved
DJI	Agras T50	227.07 lbs.	Approved
DJI	FlyCart 30*	209.73 lbs.	Approved

FAA's approval list and DJI models

2. Canada

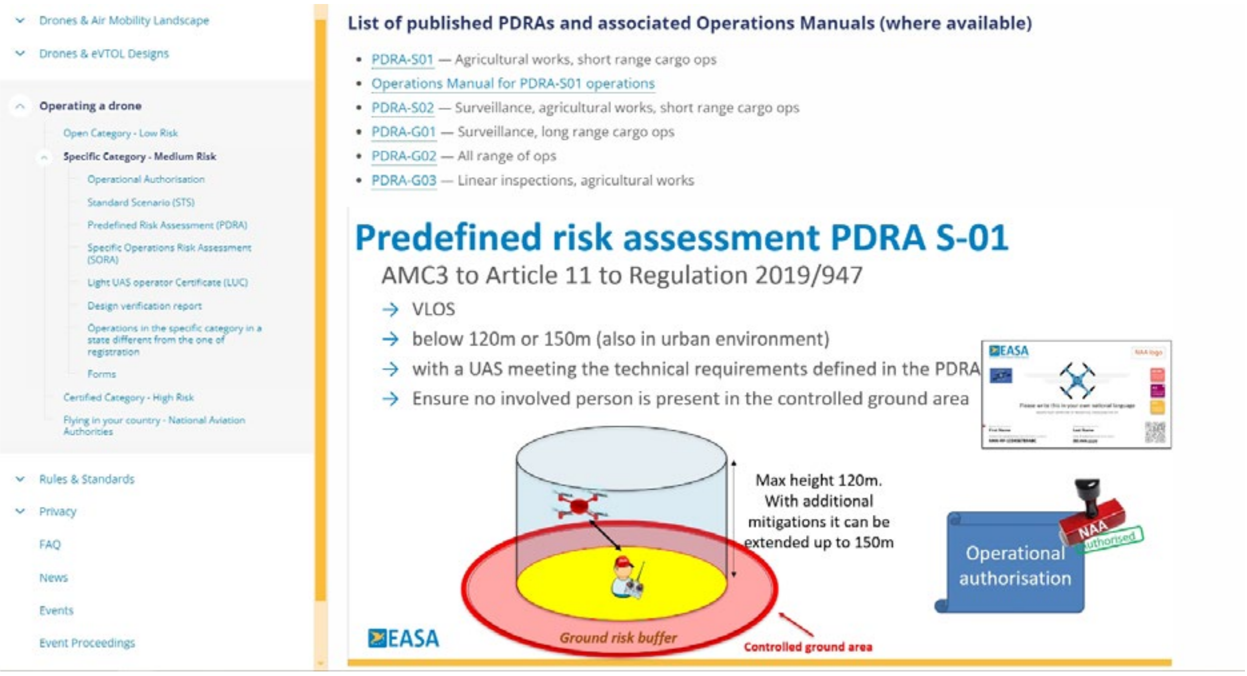
According to the requirements of Transport Canada, those who operate drones over 25 kg need to apply for SFOC.

As drones weighing more than 25 kg, users of T50 and T25 need to apply for SFOC licenses from Canadian authorities. In 2023-2024, many users in Canada successfully obtained SFOC and carried out spraying operations in Canada.

Further Opening Up of Management Policies in Europe

1. Civil Aviation Regulations

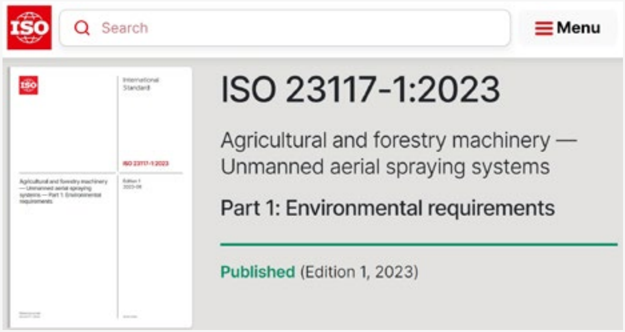
In order to better cope with the growing demand for agricultural drone approval, the European Aviation Safety Agency (EASA) has released a series of PDRAs[6] (predefined risk assessments). Among the five PDRAs, four can be used for applications for agricultural drone operations. Users can apply for different templates based on different scenarios.



PDRAs regarding the agriculture operation of EASA

2. International Standard Establishment

In 2023, DJI Agriculture participated in the construction of the ISO 23117-1[7] international standard, which specifies the requirements and methods for the design and performance verification of spraying systems on drone systems less than 150 kg. The purpose of establishing this standard is to reduce the potential environmental pollution risks during use from the perspective of design and performance.



ISO releases agricultural drone testing standards

In June 2023, the standard was officially released and adopted by EU member states. From 2023 to 2024, DJI T50 Agrasand T25 agricultural drones successively obtained ISO 23117-1 certification in many European countries.

6. See: https://www.easa.europa.eu/en/domains/civil-drones-rpas/specific-category-civil-drones/predefined-risk-assessment-pdra
7. See: https://www.iso.org/standard/74600.html

Australia

1. CASA Released Support Policy for Agricultural Drones

In May 2023, the Civil Aviation Authority of Australia published a content titled "Drones taking agriculture sky high" on its official website, which sorted out the management methods of agricultural drones, from registration to safe use, and the need to comply with the management tips of the local spraying.

The complete guidance[8] of the entire process by CASA represents recognition of the development of local agricultural drones. In the guide, special mention is made of the relaxed management of use on personal land, and no need for special authorizations when operating in accordance with safety guidelines. "There are no CASA authorizations required to conduct spraying operations when operating one drone on your own land. However, it's important you also check the local state or territory laws for aerial distribution where you intend to conduct spraying operations."

At the same time, the Civil Aviation Authority of Australia has opened compliance application channels and operation guidance for beyond visual range operations, extended visual range operations, and cluster operations.

"We recognize the benefits that drones can deliver in agricultural operations, including improved efficiency

and reduced costs. With the rapidly growing popularity and innovative advancements in the RPAS industry, we continue to work with industry to review and update our regulations as necessary to make sure they stay relevant while supporting new technologies and safety", from CASA.

2. APVMA Supports and Gives Guidance to Agricultural Drone Use

In 2023, APVMA actively organized and participated in several meetings related to the regulation and drifting risk regarding drone application, and provided certain guidance to local users on the use of agricultural drones for spraying.

8. https://www.casa.gov.au/about-us/news-media-releases-and-speeches/drones-taking-agriculture-sky-high

Agricultural Drone Industry Insight Report

Chinese Regulations Support the Development of Agricultural Drones

1. Regulations on Unmanned Aircraft System Released

On June 28, 2023, the "Interim Regulations on the Management of Unmanned Aircraft System " was officially released. This is China's first regulation specifically targeting drones. On the basis of hierarchical and classified management, namely the five categories of "micro, light, small, medium and large", agricultural drones are separately classified, and a more open management method is given.

The new definition removes the weight restriction on agricultural drone design, which provides more possibilities for the design of agricultural drones in the future.

Secondly, considering that agricultural drones are mostly below 150 kg in actual social production, the scope of use of "conventional operations" is retained, that is, agricultural drones below 150 kg have more openness in operation.

In terms of operation, agricultural drones can fly above agricultural, forestry, animal husbandry and fishery land in the suitable airspace of "micro, light and small" drones, which means that the use of agricultural drones does not require an application for flight activities in most scenarios. This can ensure that agricultural drone pilots can operate in a timely manner during the busy farming season.

Finally, in terms of license management, the pilots are allowed to get trained from manufacturers, which greatly reduces the entry threshold for agricultural drone practitioners and makes it easier for manufacturers to provide professional license training for pilots.

These new management designs open up more possibilities for the future design of agricultural drones and more possibilities for application scenarios, reflecting the country's support for the development of new quality productivity and the working principle of "delegating power, delegating control and serving" agricultural management.

2. Airworthiness Management

As of May 2024, the DJI T20P, T25, T25P, T40, T50, and T50 agricultural drones have completed all compliance verifications and validations, and are now beginning the compliance summary and preparation for the Final Review Conference.

Airworthiness ensures the safe operation of medium and large uncrewed aircraft systems. According to AP-21-AA-2022-71 "Management Procedures for Airworthiness Certification of Civil Uncrewed Aircraft Systems", there are ten phases before the CAAC officially issues a Type Certificate (TC), including TC application and acceptance, product familiarity introduction, review team formation, design assurance system review, certification basis determination, certification plan and compliance means development, manufacturing conformity inspection, compliance verifications and validations, and final comprehensive review. Among these, compliance verifications and validations are the key phase to ensure that the type design complies with all airworthiness clauses defined in the certification basis.

Since June 2023, DJI Agriculture has been to Huizhou, Nanjing, Henan, Qinghai, Sichuan, etc., to conduct compliance verification tests for the airworthiness certification of the above six agricultural drones. Under the supervision and authorization of CAAC, more than twenty compliance verification flight tests, including flight height test, speed test, flight radius test, weight and center of gravity test, flight control and navigation test, wind resistance test, 4500 m altitude flight test, DAA test, night operation test, flight envelope limit test, endurance flight test, and more than ten laboratory compliance verification tests such as battery test, electrostatic discharge (ESD) test, radiation susceptibility (RS) test, high/low temperature test, transport vibration test, IP protection test, alternating salt spray test, and pesticide and fertilizer corrosion resistance test, were conducted in accordance with the approved certification plan, along with inspection and witnessing by the CAAC review team.

Currently all compliance verification tests have been completed in sequence, including more than 760 flights total more than 3,000 flight hours. These tests comprehensively validate the functionality, performance, and fail-safe characteristics of the DJI Agras T20P, T25, T25P, T40, T50, and T50 agricultural drones.

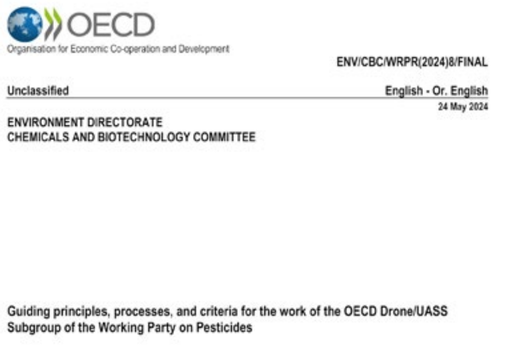
High altitude test

International Organization

1. OECD

In May 2023, the OECD held a seminar on agricultural drone operations in the UK, discussing topics such as regulations, drone technology, drifting tests and best practices. Representatives from different OECD member countries participated in the meeting and shared management experiences and future management ideas from different countries.

In 2024, the OECD released Guiding principles, processes, and criteria for the work of the OECD Drone/UASS Subgroup of the Working Party on Pesticides to accelerate the advancement of agricultural drone applications.



OECD
Organisation for Economic Co-operation and Development

ENV/CBC/WRPR(2024)8/FINAL

Unclassified English - Or. English

24 May 2024

ENVIRONMENT DIRECTORATE
CHEMICALS AND BIOTECHNOLOGY COMMITTEE

Guiding principles, processes, and criteria for the work of the OECD Drone/UASS Subgroup of the Working Party on Pesticides

Guiding principles, processes, and criteria for the work of the OECD Drone/UASS Subgroup of the Working Party on Pesticides

2. FAO-APPPC

In August 2023, the Asia-Pacific Plant Protection Commission (APPPC) of the Food and Agriculture Organization of the United Nations held a training course on agricultural drone spraying technology in Nanjing. Nearly 40 people, including representatives and lecturers from the APPPC Secretariat, the Ministry of Agriculture and Rural Affairs of China, and representatives from 10 member countries including China, Indonesia, Laos, Malaysia, Nepal, Samoa, Solomon Islands, Thailand, Timor-Leste, and Tonga, attended the training course.

APPPC training course on-site record

Agricultural Drone Tests

In 2023, DJI conducted drifting tests and efficacy tests around the world to further explore anti-drift design and best practices for drones.

Drifting Tests in China

1. T50 Drifting Test

Test Process

Three types of droplet collection devices (ground droplet deposition collector, ground drift collection device, and aerial drift collection device) are set up to evaluate the distribution of droplets in the operation area and the downwind area of the operation.

Ground Droplet Deposition Collector: In order to collect the deposition distribution in the operation area of the agricultural drone, a PVC card support device belt is arranged in the operation area of the agriculture drone to collect the deposited droplets. An 8×5 cm² PVC card (hereinafter referred to as a small PVC card) is used as a droplet collection device in the target area. The deposition droplet collection belt is perpendicular to the flight direction of the drone. The width of the deposition collection area is 22.5 m (3 spray widths). Each group has 15 points from the upwind to the downwind edge, with an interval of 1.5 m. There are 3 groups and 45 points in total. During use, ensure that the plane of the PVC card is parallel to the ground.

Ground Drift Deposition Collection Device: To collect the ground drift distribution of the agricultural drone in the downwind direction, 10 PVC cards with a size of 12x12 cm² (hereinafter referred to as large PVC cards) were arranged at 3, 5, 10, 15, 20, 30, 40, 50, 75, and 100 m downwind of the spray edge of the agriculture drone. The cards were fixed on a U-shaped aluminum groove 10 cm above the ground. The ground drift deposition collection device is on the same straight line and parallel to the drone route. Each sampling site is 1 m apart, and each group of tests has a total of 100 PVC cards.

Air Drift Collection Device: To collect air drift droplets in the downwind direction, three sets of self-built 3×2 m air drift collection frames were placed at 5 m, 20 m, 50 m, and 100 m downwind of the spray edge. On the frame, a 2 m long and 1.98 mm diameter polytetrafluoroethylene wire was arranged every 50 cm from 0.5 m above the ground to 3 m, with a total of 72 wires in each test. The ends of the polytetrafluoroethylene wire were fixed to the vertical frame with clips and stretched straight to ensure no bending. Each droplet collector device is shown in Figure 1.

The DJI T50 agricultural drone was used for this test.

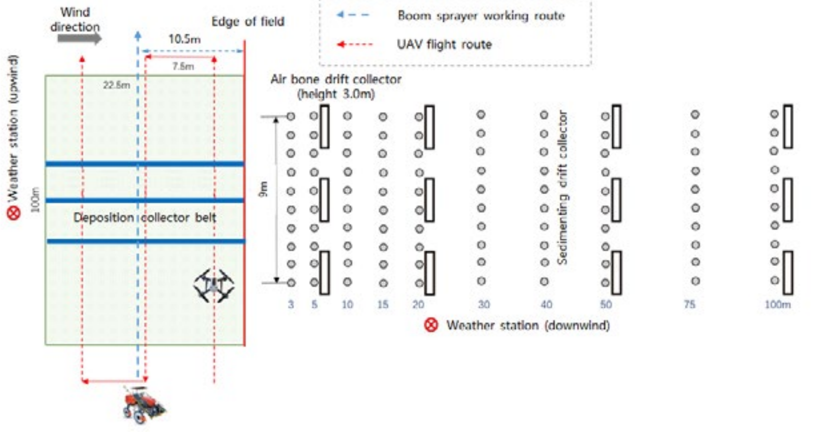
Droplet ground drift deposition collector

Droplet air drift deposition collector

Target area droplet deposition collector

In the layout of the test site, the drift test device is completely perpendicular to the route, and the weather station is turned on during the test to collect wind speed and direction. When the wind speed and wind direction meet the requirements and are stable, the operator is notified to prepare for takeoff, and the simulated liquid with a concentration of 1 g/L ABF fluorescent tracer and a concentration of 0.1% of OP-10 non-ionic surfactant is added to the liquid tank, and collectors are arranged on each collection device. The drone flies three routes with a route interval of 7.5 m. The automatic flight mode is used to call the set route for operation. The test parameter settings are shown in Table 1. Each treatment is repeated 6 times to ensure 54 effective tests. The test can withstand natural crosswind parameters: wind speed range 1-5 m/s, wind direction perpendicular to the route ±30°. After the test is completed, the samples are collected and stored in the dark and transported to the laboratory for subsequent testing. After each group of tests, no less than 10 ml of mother liquor is collected in a 50 ml centrifuge tube for analysis of deposition.

After each test, all samples (large PVC cards, small PVC cards, polytetrafluoroethylene wires, and mother liquor sampling bottles) were immediately stored away from light. Small PVC cards, large PVC cards, and polytetrafluoroethylene wires were collected and stored in plastic ziplock bags with specifications of 8 × 4 cm, 16 × 14 cm, and 18 × 12 cm, respectively. After the full-day test, the samples obtained on the day were transported to the laboratory for storage in a dark, cool place, and then the samples were processed and measured. When processing the samples, 20 ml of deionized water was added to the ziplock bag containing the large PVC card, and the oscillation was eluted on the oscillator at a frequency of 200 r/min for 5 min; 30 ml of deionized water was added to the ziplock bag containing the small PVC card, and the oscillation was eluted for 10 min; 30 ml of deionized water was added to the ziplock bag containing the polytetrafluoroethylene wire, and the bubbles were discharged and placed on a decolorization shaker for 10 min. During this period, the samples were turned over to ensure that the deionized water completely infiltrated the polytetrafluoroethylene wire. Finally, the eluents of various samples were measured in turn using a fluorescence meter and the fluorescence values were recorded.



Schematic diagram of the drifting test

Test Record

During the test, the ambient temperature was between 19-31° C, and the average humidity was 22-69%. Among the 54 test repetitions, the wind speeds during the test did not meet the test standards in T2 repetition 4, T3 repetition 5, T4 repetition 1, T7 repetition 4, and T8 repetition 4. The wind direction pass rates were lower than 70% in T6 repetition 3 and repetition 4, T7 repetition, and T9 repetition 3. The remaining test groups all met the requirements for ambient wind speed in ISO22866.

Conclusion

In this test, under the condition of wind speed of 1-5 m/s, three different flight speeds, three nozzle speeds, and three flight altitude operation parameters of the T50 were selected. A total of 9 test treatment groups were set up. Based on the above test results and analysis, the following are the conclusions:

a. The ground droplet drift generated by the spray of this model of agricultural drone is exponentially related to the sampling distance, and the ground drift deposition mainly exists in the range of 0-30 m downwind. The air drift rate of airborne drift droplets in the range of 0-5 m downwind decreases with increasing height.

b. The ground drift of agriculture drones is positively correlated with the flight speed. Reducing the flight speed can effectively reduce the risk of ground drift of agriculture drones. If the risk of air drift is effectively reduced, the flight speed of the drone needs to be controlled at 4 m/s or below.

c. The level of ground drift deposition of agricultural while the level of aerial drift increases with the increase of flight altitude. Within the flight altitude of 3 m and below, increasing the flight altitude will lead to increased ground drift, while above 3 m, increasing the flight altitude will lead to an increase in the ratio of aerial drift droplets, resulting in unpredictable drift risks.

d. The ground drift deposition of agricultural drones at a downwind distance of 0-15 m is positively correlated with the droplet size. The larger the droplet size, the higher the ground drift risk at close distances. However, the ground drift deposition is negatively correlated with the droplet size after a distance of 20 m downwind, and the aerial drift risk is negatively correlated with the droplet size at a downwind distance of 0-100 m. The drift sedimentation risk and aerial drift risk of 100 µm fine droplet treatment at long distances are higher than those of other types of flight parameter treatments.

e. Agricultural drones can reduce their flight altitude to 1.5 m or use a coarse droplet operating parameter of 500 µm Dv50 for spraying to effectively reduce droplet drift and increase ground droplet deposition. Using low drift risk operating parameters of 4 m/s flight speed, 1.5 m flight altitude, 500 µm droplet size can effectively reduce the risk of air drift. The droplet drift level produced by these operating parameters is equivalent to that of a boom sprayer at a long distance.

2.T25 Drifting Test

The purpose of this test is to clarify the drift of T25 under different influencing factors, so as to guide agriculture drones to carry out plant protection operations safely and efficiently, and ensure the safety of non-target organisms and the environment.

Test Process

The test instruments include anemometer, temperature and humidity meter, filter paper, label paper, Mylar sheet, stapler, 50 m tape measure, ziplock bag, gloves, mask, scissors, syringe, pipette, 0.22 µm water filter membrane, Varioskan Flash multifunctional microplate reader, scanner, YG-BX weather station, Depositscan software, etc.

Model	Nozzle	Nozzle Type	Nozzle Number	Flight Speed (m/s)	Flight Height (m)	Volume (L/ha)	Droplet Size (µm)
T25	LX8060SZ	Centrifugal Sprinkler	2	3/5/7	2/3/4	30	100/250/420

The test was carried out in the field of Xinxiang Demonstration Base of Institute of Plant Protection, Chinese Academy of Agricultural Sciences. The farmland is flat and open and unobstructed. According to the actual field operation experience and the results of previous studies, the flight speed was selected as 3 m/s, 5 m/s and 7 m/s, the flight altitude was selected as 2.0 m, 3.0 m and 4.0 m, and the droplet size was set to 100 μm, 250 μm and 420 μm. Each parameter combination was used to measure the droplet deposition and drift of the multi-rotor agricultural drone spray at two different crosswind speeds. The specific test treatments are shown in Tables 2 and 3.

Detailed processing of wind speeds between 1.5 and 3.4 m/s

Trials	Flight Altitude (m)	Flight Speed (m/s)	Droplet Size (μm)
1			100
2		3	250
3			420
4			100
5	2	5	250
6			420
7			100
8		7	250
9			420
10			100
11		3	250
12			420
13			100
14	3	5	250
15			420
16			100
17		7	250
18			420
19			100
20		3	250
21			420
22			100
23	4	5	250
24			420
25			100
26		7	250
27			420

TDetailed processing of wind speed between 3.4-5.4 m/s

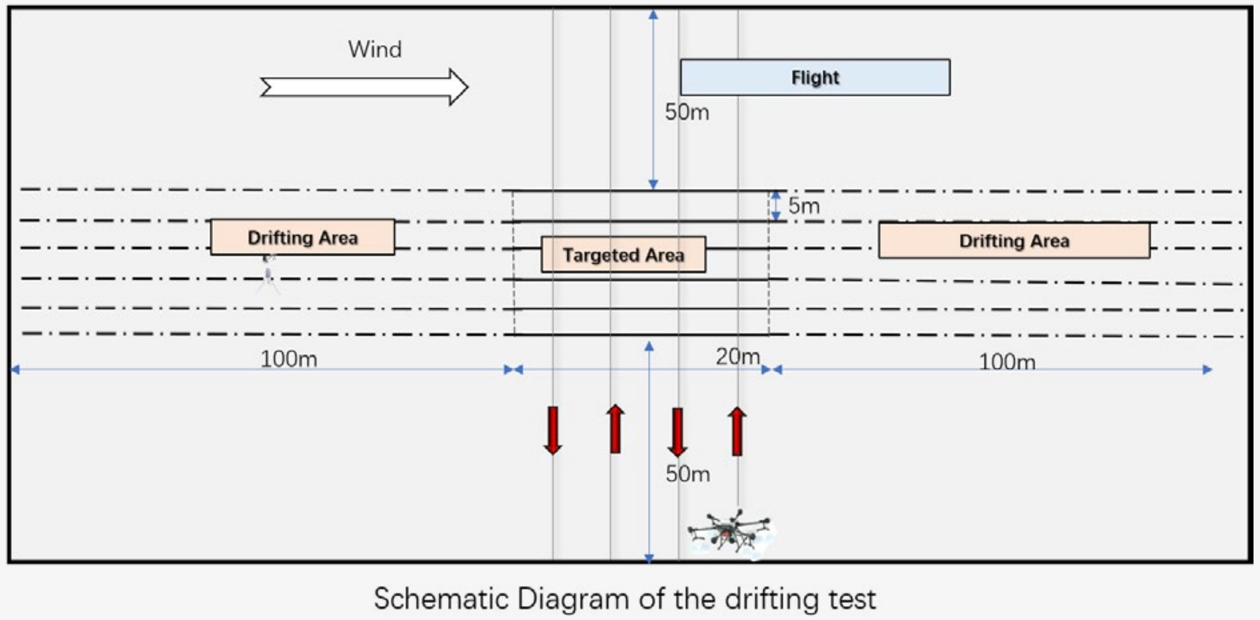
Trials	Flight Altitude (m)	Flight Speed (m/s)	Droplet Size (μm)
28			100
29		3	250
30	2		420
31			100
32		5	250
33			420
34			100
35		3	250
36	4		420
37			100
38		5	250
39			420

The sampling points are set as follows: droplet collection devices are arranged at 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90 and 100 m from the edge of the downwind working area; the droplet collection device is supported by a Mylar sheet at the bottom, the droplet test card and a filter paper with a diameter of 9 cm are fixed on the Mylar sheet, and the sampling device is placed 1 m above the ground, as shown in Figure 2. At 10, 20, 30, 50, 75 and 100 m from the downwind edge of the operation area, and 1, 2, 3 and 4 m from the ground, an aerial droplet collection device (consisting of a 5 m long telescopic ruler and a 5 mm diameter, 5 cm long stainless steel metal rod, as shown in Figure 4) was placed to collect droplets drifting in the air; after spraying, wait for 5 to 10 min to confirm that all the droplets on the filter paper are dried and then put them into 6# self-sealing bags in order, and store the samples in a dark and cool environment, and then process and measure the samples. The agricultural drone was set to the multi-spray width (n=4) automatic operation mode, and the aircraft route was 125 m long to ensure that the agricultural drone maintained a uniform speed in the sampling zone. 5 g/L of Rhodamine B aqueous solution, add the prepared Rhodamine B aqueous solution into the chemical product box to ensure that the pesticide load of the agricultural drone is half loaded. Before the test, check the operating status of the drone nozzle and calibrate its flow rate.

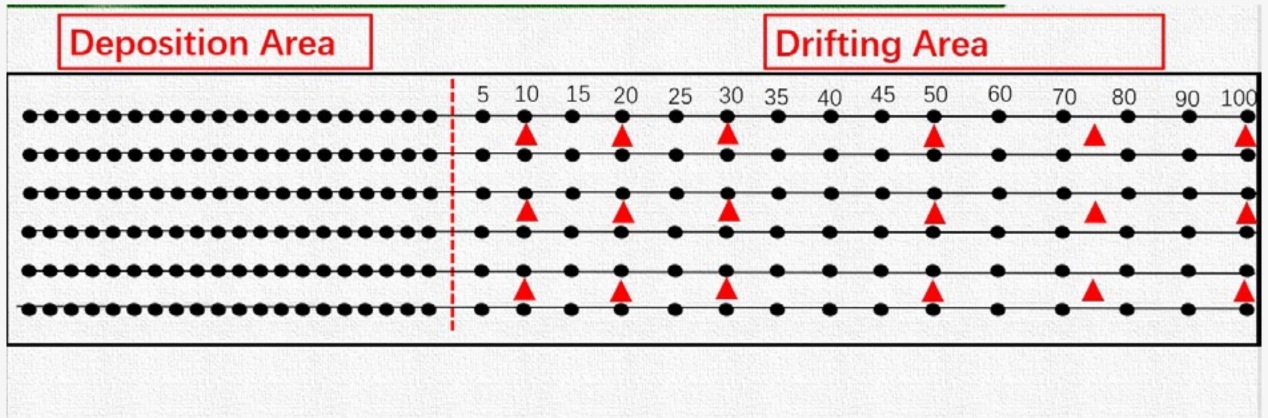
After the wind direction reaches the requirement and stabilizes, the agricultural drone takes off with one button for automatic spraying, and uses the RTK built into the aircraft

to ensure the accuracy of the route. After the spraying is completed, it will circle back to the take-off point from the upwind altitude. After each spraying, use a dark centrifuge tube to collect the spray mother solution to clarify the change in solution concentration during the actual spraying process.

Operation scene and real scene of droplet collection area



Test diagram



Collection belt layout

2. Record

Under indoor conditions, 0.0500 g (accurate to 0.0001 g) of the tracer Rhodamine B was accurately weighed using an analytical balance, and dissolved and fixed to volume with 100 ml of distilled water to obtain a Rhodamine B standard stock solution with a concentration of 500 mg/L. The gradient dilution method was used to gradually dilute the Rhodamine B standard solution to 5, 2, 1, 0.5, 0.2, 0.1, 0.05, 0.01 and 0.005 mg/L. Then, the fluorescence value was measured using an ELISA plate at an excitation wavelength of 553 nm and an emission wavelength of 578 nm. Finally, a standard curve was established with the Rhodamine B concentration as the independent variable and the fluorescence value as the dependent variable. In order to eliminate the errors caused by comprehensive factors such as the multifunctional ELISA instrument, the pre-prepared Rhodamine B standard gradient solution was added to each ELISA plate, and the Rhodamine standard curve measured on the ELISA plate was used to calculate the concentration of the test sample.

Add 5 ml of anhydrous ethanol to the zip lock bag containing the sampling filter paper, soak for 10 min until the fluorescent agent is completely eluted, and filter the solution with a syringe with a 0.22 μm water filter membrane. The treated solution is used to measure the fluorescence value of the sample eluate with a Varioskan Flash multifunctional microplate reader. The instrument parameters are set as: excitation wavelength 553 nm, receiving wavelength 576 nm.

The mylar cards collected in the test were scanned one by one with a scanner, and the scanned images were analyzed by the image processing software Deposit Scan to obtain the droplet density at different sampling points.

The data were sorted and analyzed using Microsoft Office 2019 software, and DPS and SPSS Statistics 23 were used for difference significance and correlation analysis. Origin Pro 2022 Learning Edition was used for data analysis and drawing.

The obtained data were further processed according to ISO 24253-1 and ISO 22866 standards.

In addition, in order to further refine the actual situation of droplet drift, the drift curve was fitted according to the droplet density and deposition results measured at the sampling points in the drift area, and the drift distance X was estimated through the drift curve; and the actual drift distance was determined by the deposition measured during the test.

3. Conclusion

The test studied the spray drift of the multi-rotor agricultural drone T25. Under the conditions of plant protection operation scene simulation, the spray droplet deposition and drift under different operation parameters and environmental meteorological conditions were studied. The results showed that:

1) The influence of crosswind speed on droplet drift: For the agriculture drone T25, the crosswind speed is the most important factor affecting the deposition rate of spray droplets in the operation area, the cumulative drift amount in the drift area, the 90% cumulative drift distance and the drift distance. When the crosswind speed is 1.5~3.4 m/s, the spray droplets of the agricultural drone T25 will deviate 0~5 m downwind of the operation area in the multi-spray width operation state; when the crosswind speed is 3.4~5.4 m/s, the spray droplets of the agricultural drone T25 will deviate 2~10 m downwind of the operation area in the multi-spray width operation state. The greater the crosswind speed, the higher the cumulative drift rate of the spray droplets in the ground drift area and the longer the drift distance. The droplet drift amount when the crosswind speed is 3.4~5.4 m/s is 1.94~12.11 times the droplet drift amount when the crosswind speed is 1.5~3.4 m/s. In order to reduce the drift amount of the agricultural drone and ensure the droplet deposition rate in the operation area, it is recommended that the agricultural drone T25 operate under the condition of crosswind speed less than 3.4 m/s (level 3 wind).

2) The influence of flight altitude on droplet drift: When the crosswind speed is between 1.5 and 3.4 m/s, the cumulative drift rate and 90% cumulative drift distance of spray droplets in the drift zone increase with the increase of flight altitude when the flight altitude is 2 m, 3 m and 4 m; when the crosswind speed is between 3.4 and 5.4 m/s, the deposition rate of spray droplets in the working area decreases with the increase of working altitude, and its distribution uniformity in the working area also decreases. At the same time, the higher the flight altitude, the higher the cumulative drift rate of the ground and air drift

zones. It is recommended to reduce the flight altitude as much as possible to reduce spray drift when the crosswind speed is higher than level 3 wind (3.4 m/s). When the crosswind speed is between 1.5 and 3.4 m/s, the flight altitude is reduced from 4 m to 3 m, the cumulative drift rate can be reduced by 66.88%, the flight altitude is reduced from 3 m to 2 m, the cumulative drift rate can be reduced by 55.25%, and if the flight altitude is reduced from 4 m to 2 m, the cumulative drift rate can be reduced by 85.18%; when the crosswind speed is between 3.4 and 5.4 m/s, the flight altitude is reduced from 4 m to 2 m, the cumulative drift rate can be reduced by 58.32%.

3) The effect of flight speed on droplet drift: When the crosswind speed is between 1.5 and 3.4 m/s, the droplet deposition rate in the working area when the flight speed is 3 m/s is significantly higher than that in the working area when the flight speed is 5 m/s and 7 m/s. At the same time, the droplet deposition rate in the drifting area increases with the increase of flight speed. Therefore, when the crosswind speed is between 1.5 and 3.4 m/s, it is recommended to set the flight speed to 3 m/s to reduce spray drift. When the crosswind speed is between 3.4 and 5.4 m/s, as the flight speed decreases, the droplet deposition rate in the operating area increases, and the cumulative drift rate of droplets in the drifting area decreases, but the cumulative drift rate in the drifting area still reaches more than 25%. Therefore, it is not recommended that the agricultural drone T25 operate when the crosswind speed is between 3.4 and 5.4 m/s.

4) Effect of droplet size on drift: The test selected droplet sizes of 100, 250, and 420 μm, respectively. Under these three droplet sizes, when the crosswind speed is between 1.5 and 3.4 m/s and when the crosswind speed is between 3.4 and 5.4 m/s, the droplet size is positively correlated with the deposition rate of spray droplets in the operating area, that is, the larger the droplet size, the higher the deposition rate in the operating area. When the crosswind speed is between 1.5 and 3.4 m/s and when the crosswind speed is between 3.4 and 5.4 m/s, the droplet size is negatively correlated with the cumulative drift rate, 90% drift distance and drift distance of the spray droplets in the drift area, that is, the larger the droplet size, the lower the cumulative drift rate, and the closer the 90% cumulative drift distance and drift distance. This shows that when the agricultural drone T25 is operating in a multi-spraying state, the droplet deposition rate in the operating area can be increased by increasing the droplet size, the cumulative drift rate in the drift area can be reduced, and the drift distance can be shortened.

2. Drifting Test in Australia

In July 2023, DJI Agriculture and the University of Queensland in Australia jointly conducted drift tests on the T40 and T50 to verify the nozzle design and anti-drift technology of these two models.

The drift test consists of two parts. The first part is a field test. The test method is carried out according to ISO22866. A droplet collection device is laid on the bare ground, and the T40 and T50 are sprayed and droplet collected respectively. The second part is to test the droplet particle size of the T40 and T50 in the wind tunnel of the University of Queensland.

T40 Australia drift test

Ground droplet collection device

According to the test, the T40 and T50 nozzles meet the local regulatory requirements, and the design range of droplet size can meet the anti-drifting requirements.

3. Drifting Tests in Europe

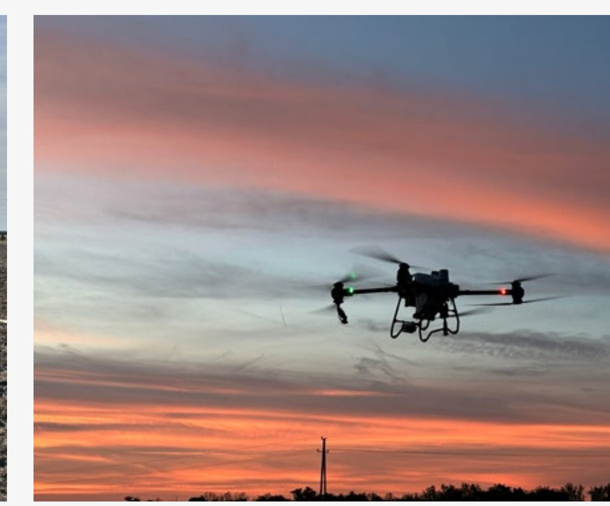
In October 2023, DJI Agriculture started the drift test of T50 in Hungary. This was the first time that T50 conducted drift test in Europe.

The test strictly followed the international standard of ISO 22866, selected a 200 x 150 m site, and placed droplet collection devices in the deposition area and drift area.

Ground droplet collection device for Hungarian drifting test

The regulations on the use of drones in Hungary have wind speed restrictions. Therefore, unlike drift tests in other regions, each set of drift tests in Hungary requires a wind speed of less than 4 m/s. In this test, the anti-drift performance of droplet diameters of 300 μm and 500 μm, as well as the effects of different flight altitudes and speeds on drift were mainly verified.

Drifting test layout in Hungary



Drifting test record

As of May 2024, the drifting test data from Hungary is still under further analysis. In the future, more tests will be carried out around the world to discuss the anti-drift design and verification of drones with the entire industry.around the world to discuss the anti-drift design and verification of drones with the entire industry.

Innovations of Agricultural Drone Application

The application of agricultural drones is an exploration and practice of the new quality productivity of "innovation-driven, green and low-carbon". Every year, new application scenarios emerge. These scenarios either improve agricultural production or solve people's life difficulties. They are worth sharing with every agricultural drone practitioner.

Spraying Application

1. Full Process Management for Mandarin Orange

Mandarin orange[9] is mainly distributed in southern China. The whole process of mandarin orange management, from promoting flower bud differentiation, orchard clearing, flower shaking, pest control, and sun protection, can now be carried out by agricultural drones.

A. Flower Bud Differentiation

Flower bud differentiation promotion management is a very important part of citrus management. The quality of management directly affects the amount of fruit in the next year. Since the harvest of Mandarin Orange has not yet ended, there are still a lot of mature fruits hanging on the trees. The tree consumes a lot of nutrients. When determining the timing of the operation, rich management experience is needed to decide the most appropriate time to carry out the first flower bud differentiation promotion operation.

Mandarin Orange will have 2-3 flower bud differentiation promotion management every year. The first flower bud differentiation promotion time generally starts in mid-to-late November, and the flower bud differentiation promotion effect is better after encountering low temperature; the second flower bud differentiation promotion time is about 20 days after the first flower bud differentiation promotion medication; if there is extreme weather, such as heavy rain or freezing rain, there will be a third flower bud differentiation promotion.

According to the different growth of fruit trees, operation techniques can be divided into the following two different techniques:

9. See:https://en.wikipedia.org/wiki/Mandarin_orange

Better Growth，Better Life

The Pesticide dosage of strong growing fruit trees

Pesticide Dosage			
Active Ingredients	Dosage Form	Volume	Effects
25% Paclobutrazol	Suspension	5.250 ml/ha	Prevent excessive growth
Amino Acids	Aqueous Solution	2.25 kg/ha	Improve resistance to adversity
Potassium Dihydrogen Phosphate	Crystals	3 kg/ha	Supplementing Nutrition
Liquid Boron + Liquid Zinc	Aqueous Solution	2.25 kg/ha	Trace Elements

a. For fruit trees with strong tree vigor, paclobutrazol needs to be added to inhibit their growth.

The Pesticide dosage of weaker growing fruit trees

Pesticide Dosage			
Active Ingredients	Dosage Form	Volume	Effects
10% S-inducible Hormone	Soluble Powder	40 g/ha	Balance Metabolism
Amino Acid	Aqueous Solution	2.25 kg/ha	Improve Resistance to Adversity
Potassium Dihydrogen Phosphate	Crystals	3 kg/ha	Supplementing Nutrition
Liquid Boron + Liquid Zinc	Aqueous Solution	2.25 kg/ha	Trace Elements

b. The trees with more fruits and weaker trees need not be treated with paclobutrazol to promote flower bud differentiation.

For specific parameters, as shown in the following table:

Parameter			
Model	T50	Route type	Regional Routes
Flight Speed	2 m/s	Altitude	4 m
Operation Row Distance	4 m	Volume	150 L/ha
Droplet size	Fine		

After 20 days, the effect of promoting flower bud differentiation in the first time was examined, and the last autumn shoot was basically mature, and there was no winter shoot, indicating that we had a better effect on flower bud differentiation for the first time. This time we only need to promote flower bud differentiation for the second time according to the usual practice.

20 days after application

Second Pesticide Dosage			
Active Ingredients	Dosage Form	Volume	Effects
2% Benzylaminopurine	Soluble Liquid	2.7 kg/ha	Delaying Work
Seaweed	Aqueous Solution	1.5 kg/ha	Medium and Trace Fertilizers
Potassium Dihydrogen Phosphate	Crystals	3 kg/ha	Supplementing Nutrition
Liquid Boron + Liquid Zinc	Aqueous Solution	1.5 kg/ha	Trace Elements

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B. Clearing the Orchard

After the orange is harvested, it is necessary to clear the orchard once or twice, so what is the clear orchard? Generally speaking, an orchard clearing is to clear the residual branches, leaves and fruits, and spraying pesticides on the orchard to kill overwintering insect eggs and pathogens, which is a thorough cleaning of the physics and chemistry of the orchard.

Fruit tree condition before orchard clearing

The main steps of clearing up are pruning, clearing residual branches, leaves and fruits, and spraying chemical product. the main purposes are as follows:

1. Pruning, cutting off withered branches, diseased branches, cross branches, overlapping branches and repeated erect branches to increase the permeability of trees, so that the sun can shine more into the inner hall of fruit trees, and at the same time facilitate the vertical application of pesticides by drones.
2. After clearing the orchard, the residual branches, fallen leaves and fallen fruit are concentrated and buried or burned, so as to prevent the overwintering eggs and pathogens from infecting the fruit trees again and reduce the pressure of pest prevention and control in the coming year.
3. Spray chemical product to remove overwintering eggs and pathogens from fruit trees, and prevent and cure pruning wound infection

Spraying Environment			
Orange Tree		Weather	
Tree Height	2 meters	Weather	Cloudy
Crown Diameter	2 m	Wind Speed	Level 2
Growing Period	Harvest Period	Temperature	15° C
Plant Protection	Orchard Clearing	Humidity	80%
Parameter			
	T50	Route type	Regional routes
Model	T50	Route Type	Regional Routes
Flight Speed	2 m/s	Operation Altitude	3.5~4 m
Usage per mu	200 L/ha	Flow Rate	/
	Operation Row Spacing	4.5 m	
Droplet Size	Fine	Flow Rate	/

First clearing

Pesticide application: 45% crystal stone sulfur mixture (50 times) + thiazox (150 times).

Operating parameters: 225 L/ha, 2 m/s, height 4 m.

Air temperature: no wind or breeze, the best temperature is 15-25° C.

Second clearing

The interval is about 10-15 days, near 3-5 days before flower bud.

Pesticide application: mineral oil (20 times) + 73% acetylene mites (200 times).

Operating parameters: 225 L/ha, 2 m/s, height 4 m.

Air temperature: no wind or breeze, the best temperature is 20-25° C.

C. Shaking Flowers.

The time of shaking flower and protecting orange is generally in March. Usually, when the flower withering rate reaches 50%, the farmer needs to shake the flower once according to the weather conditions, but usually because of the lack of manpower, farmers always choose to apply chemical product when the flower withering rate reaches 70%-80% to prevent gray mold. If you encounter cloudy and rainy weather, you need to shake flowers urgently. However, because manual shaking takes time and effort, it may not be able to shake the flowers in time, so the prevention of Botrytis cinerea in the later stage increases the management cost.

If agricultural drones are used, farmers can choose to shake flowers one or two times during the flowering period to control thrips and red spiders, while saving pesticide and labor costs to prevent and control Botrytis cinerea. Shaking flowers in the early stage of drone can also improve the appearance and income of mature fruit.

By comparing the effect of artificial flower shaking with that of drone, the flower shaking effect of drone is not only much higher than that of artificial, but also equal to or better than that of artificial, because the petals glued to leaves can also be blown off in the strong wind field of drone. On the contrary, artificial flower shaking is very difficult to shake off the petals glued to the leaves.

D. Red Spider Control

In order to achieve better control effect, use Mavic 3M orchard aerial survey and reconstruct three-dimensional map, plan orchard three-dimensional route, and verify the stability and safety of the route; calibrate the spraying flow of T50 to ensure that the accuracy reaches the standard and the control is stable.

Red Spider Mite Control Operation Parameters			
Model	T50 Four Sprinkler Kit	Route Type	Three-Dimensional Route-Regional Route
Flight Speed	1.5 m/s	Operation Altitude	4 m
Operation Row Distance	4 m	Amount per Acre	300 L/ha
Droplet Size	80 μm		

E. Spraying Sunscreen

Every summer, the sunshine is getting longer and longer, and the temperature continues to rise. In addition, with the return of El Nino this year, it is expected that there will be a hotter midsummer than in previous years. In addition to the hardship of human beings, the trees also suffer from the hottest summer in the world. Wise farmers are always trying to find ways to protect their orchards from the sun.

Spraying a white sunscreen on orange trees can not only protect the sun from the sun, but also reduce the harm of diseases and insect pests to a certain extent, but also has a good effect on the color conversion of the fruit during the expansion period, making the color conversion more uniform and the fruit better.

Effect of sunscreen spraying(450L/ha)

Spraying Environment			
Orange Tree		Weather	
Tree Height	2 -2.5 m	Weather	Sunny
Crown Diameter	2 m	Wind Speed	Level 1
Growing Period	Fruit Expansion Period	Temperature	32° C
Task	Spraying Sunscreen	Humidity	90%
Parameter			
	T50	Route Type	Regional routes
	2 m/s	Operation Altitude	5 m
Model	T50	Route Type	Regional Routes
Flight Speed	2 m/s	Operation Altitude	5 m
Usage per mu	450 L/ha		
	Operation Row Spacing	4 m	
Droplet Size	320 μm	Flow Rate	/

2. Spraying Operation for Korean Pine

Pinus koraiensis, commonly known as the Korean pine, is a highly valuable species. It serves as a precious timber source, an economic tree, and a crucial component for soil and water conservation. The trunk of the Korean pine is prized for making high-quality furniture, while its needles are used to extract pine needle oil, and its roots are utilized to produce industrial raw materials such as rosin. Additionally, Korean pine kernels are considered a natural green food, rich in fatty acids, proteins, and various vitamins. China boasts approximately 30 million hectares of natural Korean pine forests, highlighting the significance and abundance of this species.

Natural Korean pine forests are scattered (the ones marked with red circles are Korean pine)

10. See: https://en.wikipedia.org/wiki/Pinus_koraiensis

Korean pine trees are inevitably affected by various diseases and insect pests during their natural growth. Common diseases include blight, skin rot, spot disease, and pine wilt disease, with pine wilt disease being considered the "cancer" of pine trees. Once detected, it can cause large-scale die-offs, necessitating extensive felling and burning to curb its spread. Pine pests include the pine caterpillar, pine brown longicorn beetle, pine tip weevil, red pine ball aphid, and pine tip borer.

Due to the towering height of natural Korean pine forests, which can reach up to 30 meters, and the location of the pine cones at the high canopy, traditional manual control methods pose significant challenges. One such method involves manually releasing matrine smoke to diffuse and fumigate pests among the red pine nuts. Alternatively, large fixed-wing aircraft are used to spray liquid pesticides, but these methods are both difficult and expensive.

Red pine trees withered due to pests and diseases (the grayish white ones are withered red pine trees)

In recent years, the price of Korean pine cones has continued to rise. This is primarily due to the low yield of Korean pine seeds; a single cone weighs about 400-600 grams, and it takes more than three cones to produce 500 grams of Korean pine seeds. Additionally, Korean pine trees typically have "a small harvest every three years" and a "big harvest every five years," which naturally drives up the annual price of the cones. Harvesting is further complicated by the fact that the cones grow at the top of the crown, making them very difficult to pick.

However, with the popularization of agricultural drones, the difficulty of pest control in both natural Korean pine forests and plantations is gradually decreasing. This technological advancement is attracting more contractors to invest in and manage natural Korean pine forests.

To control diseases and insect pests in Korean pine forests using the T50, users typically employ a cross-star pattern on the remote control to circle the ground, activate the multidirectional obstacle avoidance function in field route mode, select mountain/fruit tree mode in the operation scene, and enable both the height setting and detour functions. Since Pinus koraiensis is an evergreen species with five needles per bundle, an aerosol spray at a height of 10-15 meters relative to the crown can effectively cover the pine cones at the top. This approach ensures effective pest control while enhancing operational efficiency.

However, it is important to note that the tall stems of natural Korean pine forests can obstruct the remote control signal. Therefore, ensure the remote control is positioned at a commanding height in a flat and open area. Alternatively, take off and land in the flat and open gullies between mountains or use 4G to enhance the map transmission function.

Table 11 T50 Korean pine natural forest operation parameters

Model	T50	Flight Speed	6-7 m/s
Relative Crown Height	10-15 m	Operation Row Spacing	7 m
Volume	30 L/ha	Droplet Size	150 μm

At present, the effect of agricultural drones working on Korean pine trees has also been preliminarily verified. Agricultural drones can not only help Korean pine natural forest to control diseases and insect pests, but also increase income with abundant fruit pesticides. According to feedback from users of T50 agricultural drones in Dunhua City, income can be increased by more than 15% after using agricultural drones to control Korean pine diseases and insect pests. Take the Korean pine tower without control as an example, the weight is about 250 grams, and after using drones to control diseases and insect pests with fruit chemicals, the average weight of the Korean pine tower reaches 400 grams. Behind this bumper harvest data is the protection of Korean pine forest from being eroded by diseases and insect pests. It is also a witness to the take-off of agricultural science and technology.

Leafhopper Control

The control of tea plant diseases and insect pests is the key technology of tea plantation field management. At present, the main tea diseases and pests are anthracnose, tea small green leafhopper, gray tea inchworm and mites, which are usually controlled by artificial knapsack sprayer. however, there are some problems in artificial spraying, such as uneven spraying, low efficiency, unsafe operators and so on. Drone operation can solve the above concerns of tea farmers.

A Tea Plantation in China

Empoasca

Empoasca is a genus of leafhoppers, which is one of the common pests in tea plantation. it can reproduce for 10 to 14 generations a year, and generations alternate. The adults and nymphs feed on the juice of buds and leaves, which is very harmful to summer and autumn tea, and has a great impact on tea yield and quality. Therefore, it is necessary to control the insect population to the lowest level before picking tea in late spring.

Prescription			
Active Ingredients	Form	Volume	Effect
Cypermethrin, Tolfenpyrad	Suspension	1350 ml/ha	Red spider mites and tea cicadas
Phenoxy Ether, propiconazole	Emulsifiable	450 ml/ha	Spotted leaf disease
Chloranil, Etoxazole	Suspension	675 ml/ha	Red spider mites and tea cicadas

Symptoms of damage caused by tea green leafhopper

The tea small green leafhopper itself is light green, it is difficult to find hidden in the leaf buds, and it can fly and jump, and the adult nymphs can easily escape from the liquid spraying when spraying pesticides, and the control effect is not good; but when the drone sprays pesticides, the flight speed is faster and the wind field is larger, which can well suppress the flying jump of the tea small green leafhopper, and the control effect is better.

DJI T50 tea plantation operation

Condition			
Tea Tree		Weather Conditions	
Tree Height	0.8~1m	Today's Weather	Cloudy
Tree Width	1.2m	Wind	≤Level 2
Growing Period	Summer tea picking	Temperature	13~17℃
Plant Protection Management	Tea leafhopper control	Humidity	94%
Operation Parameters			
Model	T50	Route Type	Regional Routes
Flight Speed	4 m/s	Operation Altitude	3.5~4 m
Usage per mu	120 L/ha	Operation Row Spacing	4.5 m
Droplet Size	Fine	Flow rate	/

Spreading Application

1. Cover Crop Spreading

With climate change and natural resource degradation, soil problems are becoming increasingly serious. Ensuring soil nutrition and protecting biodiversity has become a common concern worldwide.

“Soil is the foundation of our agricultural systems, the home of biodiversity, and the ‘green water’ reservoir for our plants,” by FAO Director-General QU Dongyu, at the 12th Plenary Session of the Global Soil Partnership held in 2024.

The use of agricultural drones has further explored new ways to solve soil problems on the basis of traditional solutions.

The use of agricultural drones has further explored new ways to address soil problems based on traditional solutions. Cover crops, which are planted on bare land during periods when cash crops are not grown, such as during the slack season between two crops, serve two main purposes: they prevent soil erosion by rain and maintain water and soil integrity, and when plowed into the soil, they increase soil nutrients and act as green manure crops.

In particular, planting legume cover crops can fix nitrogen and significantly improve soil fertility recovery. Common green manure crops include legumes such as broad beans, wild peas, mustard, alfalfa, rye, and clover.

Cover crops have become increasingly common around the world in recent years. Take the United States as an example. Between 2012 and 2017, the planting area doubled from 5 million acres to 10 million acres. The history of cover crop planting in Europe is as long as hundreds of years. In the past, the sowing of cover crop seeds was mainly done by ground tractors. But with the promotion of agricultural agriculture drones, more and more farmers are aware of the benefits of drone operations.

In Germany, farmers and service providers have jointly changed the "ploughing and spreading mode of using large tractors. In the past, such spreading operations could only wait until the cash crops were harvested. Not only could the nutrients of the land not be replenished in time, but the drying after turning the soil would also cause damage to the biodiversity in the land and further damage the soil's water storage capacity.

Using agricultural drones, cover crop seeds, including leguminous crops such as alfalfa and yellow mustard, can be sown two weeks before the harvest of cash crops like wheat. This approach offers several advantages: it eliminates the need to destroy the existing cash crops while advancing the growth window for green manure crops. By the time the cash crops are harvested, the green manure crops have already sprouted, making them less vulnerable to sudden cold or hot weather that could lead to low germination rates. Additionally, this method prevents casualties among beneficial organisms like earthworms since large machinery does not need to enter the fields to turn the soil.

Mixed seeds of cover crops

11. See: https://www.fao.org/newsroom/detail/global-soil-partnership-assembly-discusses-how-to-meet--ambitious-and-urgent--target/en
12. See: https://www.schmidt-solutions.de/

Another advantage of using agricultural drones to spread cover seeds is that they can be used before or after rain, with more flexible operation times and higher germination rates. Even after a heavy rain, when large tractors cannot enter muddy farmland for operations, drone operations can be arranged as usual. Even on light rainy days, the spreading of agricultural drones is not affected.

T50 spreading seeds in light rain

After long-term operation of ground tractors, the soil will be compacted and hardened, affecting crop yields. As a non-contact operation tool, drones completely avoid this problem. After green manure crops grow, they will increase the nutrients in the soil. Leguminosae can play a role in nitrogen fixation. The water retention capacity of the land nourished by green manure crops is further improved, which enhances the buffering capacity of the soil and ultimately increases food production.

Figure 1

Figure 2

Figure 3

Figure 1 Land with earthworms
Figure 2 Cover crops add nutrients to the soil
Figure 3 Earthworms living in the soil

In 2023, the area of cover crop spreading by DJI Agriculture drones reached about 46,000 hectares in the United States and about 6,700 hectares in Germany. More and more farmers benefited from this new operation method, which not only improved the success rate of spreading, but also reduced the damage to the yield potential of arable land.

2. Rice Spreading

Rice is a cereal grain and it is the staple food of over half of the world's population, particularly in Asia and Africa . Rice is usually planted in two methods: transplant, and direct seeding. The practice of transplanting consists of four steps: nursery bed preparation, seedling raising, seedling uprooting, and transplanting the seedling into the main field. Unlike transplanted rice, direct seeded rice does not require seedling raising in the nursery bed but instead directly seeds into the main field.

Direct seeding is a common practice in some countries like US and Australia. In US, all rice fields are seeded by direct seeding, while 20% is done with airplane. But in Asia, transplanted rice is more common in conventional practices. However, transplanted rice has been increasingly replaced by direct seeding due to significantly lower labor requirement even in Asian countries. In Malaysia, area of direct seeded rice increased from 0 to 50% in the past 10 years. In Thailand, area percentage of direct seeded rice is 34%, while in Philippines and India, it is around 30% .

The introduction of DJI AGRAS drone technology into these countries improves the feasibility of rice direct seeding. Using drone for rice direct seeding enhances operation efficiency and spreading precision comparing with manual seed spreading, and eliminates the hazard of being trapped in muddy paddy fields which is common to ground seeders. Therefore, it’s becoming more and more popular in rice farming countries.

13. See: https://en.wikipedia.org/wiki/Rice
14. See: https://xuebao.scau.edu.cn/zr/html/2019/5/20190501.htm

Smart Agriculture

1. Agricultural Drones Propel Thailand's Durian Industry Into a New Era

The Durian, a fruit native to Malaysia, is prominently found across Southeast Asia. Of all the regions where it grows, Thailand's production of Durian stands out as the highest in the world. The Golden Pillow variety, in particular, is a renowned Durian type from Thailand.

In recent times, durian has seen a surge in popularity within the Chinese market. This has led to a substantial increase in both the cultivation area and export volumes of Durian from Thailand. However, this growth demands meticulous care to maintain production levels. There are numerous pests and diseases that can affect Durian trees all year round, with aphids being the primary concern. Other pests such as leafhoppers, thrips, psyllids, and spider mites also pose threats. These pests can harm the Durian tree leaves, hampering photosynthesis, which could potentially lead to lower yields than expected, thereby impacting revenue.

Aerial photo of durian orchard

Thailand's durian cultivation sees two major periods of intensive care each year. The first period, from July to December, coincides with the country's rainy season and the durian leaf growth stage. The warm, moist climate during this time is a hotbed for pests and diseases, while heavy rains can lead to significant nutrient depletion.

The second critical phase spans from January to March, which aligns with the flowering and fruit development stages. During these peak care periods, it's necessary to apply foliar fertilizers and pesticides anywhere from 3 to 6 times per month to ensure optimal health and productivity of the durian trees.

Two or three years ago, local farmers gradually began to explore new spraying modes, using P4R for aerial survey, DJI mapping software to build maps and generate automatic routes, and T30 for spraying. Later, he began to use the Mavic 3 multispectral version for aerial survey, used DJI Map software to build maps, and then used the T40 for spraying.

Durian Spraying Operation

For operations in the durian orchard, Mavic 3M is first used to conduct aerial surveys to take hundreds of photos of the orchard, view the overall overview of the plot, understand the growth of the durian trees, determine whether there are any pests and diseases, and collect basic information for the operation plan.

Then, photos taken during the aerial survey were imported into DJI Terra software to start the image reconstruction. The photos were generated into a three-dimensional map, and AI was used to identify the durian trees and obstacles in the map. If the machine sprays the area, such as the automatic equidistant route, click "Generate 3D Channel". The 3D channel will appear above the durian tree. You can adjust the overall height, the width, and the angle of the spraying operation and the smoothness of the route on the software. In the latest DJI Terra, users can flexibly adjust the height of a certain waypoint on the map to ensure that the drone spraying operation is efficient and accurate.

The T40 sprays accurately according to the generated route.

In Thailand's long rainy season with a brief window for crop spraying, drones have proven their worth by significantly reducing the time and resources needed for this crucial task. For instance, it takes about 4 days to manually spray a 90-rai durian orchard, while a drone accomplishes the same task within 1-2 days. Furthermore, during the summer of 2023, when a new type of aphid rapidly spread across crops, drones were able to respond swiftly within the tight 2-3 day timeline for emergency spraying, a feat often unachievable with manual methods.

Traditional manual operation

Agricultural drones address numerous challenges associated with manual spraying. Firstly, the labor-intensive and health-risk laden nature of pesticide application makes it difficult to recruit and retain workers. This is a significant problem for durian orchard owners, especially during peak farming periods.

Secondly, manual spraying often leads to excessive pesticide use due to its lack of precision, resulting in waste. In comparison, agricultural drones can reduce chemical usage by 20%-30% for the same area.

Lastly, from a coverage perspective, drones can access treetops - a common habitat for pests - which is nearly impossible to achieve with manual spraying. Therefore, drones not only increase efficiency but also enhance the effectiveness of pest control.

Spraying Method	Water Consumption / Rai (L)	Chemicals Concentration	Chemicals Cost (Baht, Thai Currency)
Manual Spraying	333.33	1	333.33
Airblast	166.5	1.5	249.75
Agras Drone	30	5	150

The cost of spraying a 90-rai durian orchard is 540 baht (calculated based on 40 operations per year)
Compared with manual labor, agricultural drones can save 659 baht in cost.
Compared with the Airblast spray truck, the agricultural drone can save 359 baht in cost.
*The frequency and cost of durian spraying vary due to annual harvest changes.

Operation Parameters

Model	T40	Flow Rate	12 L/min
Speed	1-1.5 m/s	Height	3.5 m

While agricultural drones might be a costly investment for local Thai farmers, their benefits significantly outweigh the costs. These drones not only enhance spraying efficiency but also address the critical issue of rapid pest and disease control, which is often hampered by labor shortages. They surpass the limitations of manual labor and traditional farming machinery. Given the tall stature of durian trees and their growth in mountainous terrains, certain areas are challenging to reach with conventional spraying methods. The adoption of agricultural drones has led to improved crop yields, minimized economic losses from pests and diseases, and enhanced worker safety.

2. Agricultural Drones Operating In The Middle And Late Stages Of Corn Production

Corn is one of the most widely grown food crops in the world, and is also an important feed and industrial raw material. The United States is the world's largest corn producer, followed by China, Brazil, Argentina, etc.

China and the United States are the two most important countries for corn cultivation in the world. China's corn planting area has maintained more than (40 million ha) all year round. The main planting areas include Northeast China, North China, Northwest China and Central and South China. The Northeast China is particularly suitable for corn cultivation and growth in climate, soil and other environmental conditions, so it is called the "Golden Corn Belt".

With the continuous advancement of drone technology, its advantages in mid- and late-stage corn operations are particularly prominent.

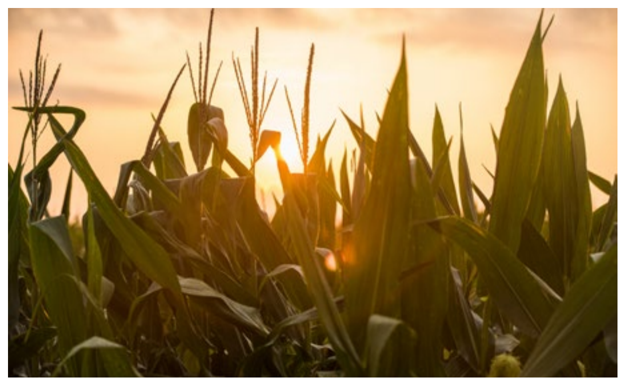
1. High-efficiency operation capability. DJI Agriculture drones are equipped with advanced flight control systems and spraying equipment, which can quickly cover large areas of corn fields. Compared with traditional manual or ground mechanical spraying, drones can complete operations in a shorter time, greatly improving operation efficiency.

2. Accurate application of pesticides and fertilizers. The intelligent navigation system and precision spraying technology carried by DJI Agriculture drones can ensure that pesticides and fertilizers are evenly distributed in the field, reduce drug waste, and avoid the impact of excessive application on the environment and yield.

3. Reduce crop damage. Since drone flight operations do not require contact with crops, mechanical damage to corn plants can be minimized, especially in the mid- and late-stage when corn is growing vigorously.

4. Flexible operation time. Corn growth requires high temperature and relatively suitable humidity, and the stem height in the mid- and late-stage is 2-3 m, with poor ventilation and light transmission conditions, and it is very easy to cause various diseases and pests, and it is difficult to detect them in time. DJI Agriculture drones can operate in a variety of weather conditions, which provides greater flexibility and timeliness for corn pest control.

4. Data monitoring and analysis. Drones can not only complete pesticide spraying and fertilization, but also be used to monitor corn growth and maturity, providing data support for precision agriculture.



The above application of drone technology in the corn planting process can bring many effects to corn:

1. Increase yield. Through precise and timely prevention and control of pests and diseases, drone technology can help farmers increase the yield per unit area of corn. Reducing crop damage and improving the efficiency of pesticide application can help corn grow healthily, thereby increasing yield.

2. Improve quality. Accurate pesticide application can effectively control pests and diseases, reduce lesions and pests on corn kernels, and improve the appearance and internal quality of corn. At the same time, reducing the use of chemical pesticides can also help improve the food safety of corn.

3. Promote sustainable agriculture. The application of drone technology reduces the use of chemical substances, helps to protect soil and water resources, and promotes the sustainable development of agriculture.

Agricultural drones have significant advantages in the mid- and late-stage operations of corn. It not only improves operating efficiency, but also plays a positive role in improving corn yield and quality. With the continuous advancement of technology and the growth of market demand, agricultural drones have huge market potential in corn operations.

3. Revolutionizing Weed Spraying in Pastures

Pasture is a predominant land use for the globe's agricultural areas, with Australia ranking second in the world for countries with the most pasture lands. These lands are primarily grazed by beef, sheep, and dairy livestock. It is forecasted that the total value of livestock exports from Australian agriculture will reach 27.46 billion Australian dollars in the fiscal year of 2023.

One of the significant challenges faced in these pastures is the infestation of blackberries, a species that is notoriously difficult to control. If left untreated, blackberries can overrun entire paddocks, inhibiting the livestock's ability to move freely and graze. This scenario can lead to significant economic losses.

Wild Blackberries

James Lyon, Director and Chief Pilot of Lyon AG[15] Drone Solutions, has been providing mapping and spraying services on pastures for over two years. James initially entered the agricultural drone industry with the intention of utilizing AI to detect and spot spray nodding thistles, a noxious weed typically managed through traditional manual methods. Manual removal, however, cannot eradicate all the roots, and other methods such as burning or biological control may adversely affect the ecosystem. Through his tests and practices, James found chemical control to be the most reliable method.

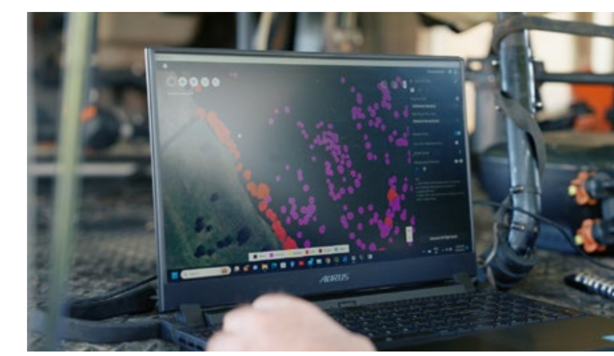
James's initial idea of getting into the agricultural drone industry was to be able to AI detect and spot spray nodding thistles, a noxious weed that farmers typically spot spray through traditional methods, primarily manual spraying off quad bikes or side-by-sides. Manual removal can't remove all the roots, burning might destroy the ecosystem, biological control has limited option and might bring risks to the local ecosystem. And chemical control is the most reliable method according to James's tests and practices.

So, he did quite a bit research into spray drones, mapping drones and started to provide service with a T20 two and a half years before.

To carry out this method, he undertook extensive research into spray drones and mapping drones and began to provide services with a T20 drone two and a half years ago.

Aerial surveying with Mavic 3M or other multispectral drones

These drones can survey 57 ha in 30 minutes with centimeter-level accuracy. The drones' Terrain-Follow feature adjusts the flight height based on the actual terrain of the pasture field. The multispectral and RGB cameras efficiently monitor pasture growth and accurately identify weed locations.



DJI Terra combined with algorithms to identify weed locations

15. See: https://lyonag.com.au/

Operation Parameters

Model	Agras T40	Flow Rate	50 L/ha
Height	3 – 6 m depending on terrain and the height of trees	Line Space	7.5 m
Speed	18 km/hr (5 m/s)		

Enhancing Operation Safety & Reducing Labor Intensity: The Significance of Agricultural Drones

Using drones in agriculture significantly enhances operational safety and reduces labor intensity. Pastures in Australia are often located on steep slopes, making it challenging for traditional machinery and vehicles to access them. Drone technology allows operators to work at a safe distance with minimal chemical exposure.

50% Cost Savings Achieved with 51% Chemical Reduction

Using agricultural drones for weed management can result in a 50% cost reduction and a 51% reduction in chemical usage. They cover various pasture management needs such as fertilizer management, weed control, pest and disease control, soil, and seed management. The benefits of these solutions are increasingly recognized in Gloucester, where James's service team is based.

Breakdown:

	Total Area	Area Sprayed	Application Cost	Chemical Cost	Total Cost
Drone	300 ha	153 ha	17,000 AUD 10,947 USD	38,250 AUD 24,631 USD	55,250 AUD 35,579 USD
Helicopter	300 ha	300 ha	37,500 AUD 24,148 USD	75,000 AUD 48,297 USD	112,500 AUD 72,445 USD

Advancing Eco-Friendly Agriculture: Towards a Sustainable Future

In addition to the economic benefits, precision spraying reduces damage to the local ecosystem. Traditional spraying methods, like helicopter sprays, often result in non-targeted species being killed, causing unintended plant destruction and potential harm to local ecosystems.

Precision farming, which combines multispectral and agricultural drone technologies, is a revolutionary technique that enhances the efficiency and productivity of agricultural production. It allows farmers to apply fertilizers, insecticides, and herbicides accurately and sustainably, thus paving the way towards a sustainable future in agriculture.

While agriculture is may be considered one of the most inefficient industries, it is also experiencing a growing number of innovations. This season, a farm in the Midwest, USA, adopted a spot spraying solution using DJI drones and Agremo AI weed detection to precisely target weed infestations.

Weed management is an almost mandatory part of a farmer's life. On a normal corn soybean rotation farm, studies show that controlling volunteer corn could prevent a 15% and 60% yield loss from individual and clumped volunteer corn, respectively. Furthermore, the farmer saved money by opting for spot treatment instead of a blanket treatment. By using drone imageries and Agremo's weed detection function, 3.75 acres of individual volunteer corn and 6 acres of clumped corn infestation was found in this 64-acre soybean farm. The farmer then flew DJI's spraying drone, T30, to spot treat these volunteer corn. As a result, he only used 60% of herbicide, and his crops were spared losses due to wheel track damage. In the end, the farmer saw a 68.39% boost to his income by opting for spot treatment over flat treatment.

These results validated the technical feasibility and economic return of mapping + AI analysis + spot spraying for precise treatment in agriculture.

The Combination of Agronomy and Drone Application

1. Wheat Seed Spreading

Wheat's legacy is tangible in every slice of bread, each mouthful of pasta, and countless pastoral vistas. From ancient civilizations to modern societies, wheat has played a crucial role in feeding the masses and sustaining economies. It is grown worldwide, underscoring its importance across cultures and eras. In 2023, data from the U.S. Department of Agriculture (USDA) revealed that worldwide wheat production reached a striking 786.701 million metric tons. Leading the charge in production were China, the European Union, India, and the United States, with China leading at approximately 17% of the global total, equating to 136.590 million metric tons. In the United States, wheat production, encompassing winter, spring, and durum varieties, was estimated at 1.81 billion bushels (49.3 million metric tons), harvested from an expanse of 37.3 million acres (15.1 million hectares).

Wheat seeds spread by drones on wet ground

However, with traditional wheat farming methodologies facing modern challenges head on, the emergence of drone technology in agriculture presents a renaissance in crop management. Agricultural drones can not only spray pesticides on wheat, but also spreading seeds. By using agricultural drones to spread wheat seeds evenly on the wet ground.

2. Uncrewed Demonstration Orchard

In February 2023, DJI Agriculture held a press conference at a 10-hectare navel orange demonstration orchard situated in complex hilly terrain. The challenge was for a single farmer to use agricultural drones to manage the entire annual operation—from clearing the orchards to harvesting. Through online adoption, tens of thousands of adopters witnessed the feasibility of managing an orchard entirely with drones.

After 230 days, the demonstration orchard finally celebrated a bumper harvest in December. The estimated output reached 250,000 kg, saving 240,000 kg of water and reducing costs by $15,146.92. Managing the orchard with a single-person drone proved to be a complete success.

In this demonstration, DJI Agriculture solution engineers empowered orchard owners to manage a 10-hectare navel orange orchard with DJI Agras T50 agricultural drones, Mavic 3M aerial survey drones, DJI Terra, and other advanced technical equipment. Tests showed that the average sugar content of Yunshang Jiangguo navel oranges exceeded 14°, resulting in a soft, sweet taste with abundant juice.

In addition to ensuring fruit quality, the comprehensive management model using drones has achieved cost reduction, increased production, and promoted green environmental protection.

The efficiency and effectiveness of drone technology in orchard management have been verified, and these economic and agricultural solutions are now being replicated in other sectors.

Cost estimation

Data	2023	Last year	Savings and ROI
Harvest (kg)	250,000	200,000	Increase in 25%
Water Use (kg per application)	1,500	1,200	Reduction of 10,500 kg
Chemical Cost (USD per year)	$6,900	$15,100	Savings of $8,200
Labor Cost (USD per year)	$0	$6,900	Savings of $6,900
Total Cost (USD)	$15100		

10-Hectare Navel Orange Demonstration Orchard

Challenge the whole process drone management

Drones Spread Snow-melting Agent

In February 2023, a wide range of rain, snow and freezing weather occurred in the central and eastern part of China, which brought challenges to travel and industrial and agricultural production.

DJI Agriculture drones have been put into snow melting, snow removal, ice removal operations.

The application scenario of drones is being expanded in extreme weather.

It is understood that since the morning of the 4th in Shishou, Hubei, many factories have collapsed because of too much snow, losing dozens or even millions of yuan, and many factory owners urgently put forward the need for snow removal.

Local drone pilots removed snow from two factories on the 4th, and as of 2pm on the 5th, snow removal operations had been carried out for five factories on the same day.

In addition to the factory building, DJI's agricultural drones are also used to remove snow in vegetable greenhouses. On February 4, a pilot in Wuhan City received a call from vegetable growers who offered to remove snow from 50 vegetable greenhouses where they grow lettuce. With the help of agricultural drones, the pilot completed the snow removal mission in more than an hour.

Using industrial salt to remove snow has the effect of melting snow in about half an hour and completely melting in about four or five hours.

Drones spread snow-melting agent

In Hubei and Henan, agricultural drones are also involved in road salt and snow removal operations, which are organized and carried out by local emergency management departments. " In the past, agricultural drones have also been used to remove snow and ice, but in the past, the snow cover is thin and the application is less.

Drones have played an important role in this year's heavy snow. " The local pilot said.

From “Transplanting Silkworms” to Spraying Pesticides, Drones are Changing This Ancient Industry

Oak belongs to the genus Quercus of the Fagaceae family. It can grow up to 30 meters in height. Because of its hard wood, high wood density and natural fragrance, it can be used to make various precious furniture. After raising oak silkworms on oak trees for a period of about 5 years, the oak trees are generally cut in rotation, and the branches cut in rotation are used to cultivate various edible fungi such as black fungus and shiitake mushrooms. Oak trees can be said to be not only a "cash cow" for silkworm farmers to make a fortune, but also an important participant in soil and water conservation, windbreak and sand fixation.

Oak leaves are rich in carbohydrates, proteins, cellulose and other ingredients, which are important food for oak silkworms. Oak silkworms can be raised in spring and autumn in a year. The breeding time for spring silkworms is generally from the end of April to the beginning of July, while the breeding time for autumn silkworms is generally from the end of July to the beginning of October. "There are more than 200 wooden square boxes in the room with an indoor area of about 100 square meters. There are about 1,200-1,300oak silkworms in each wooden square box. In this way, the total number of oak silkworms is about 300,000. These oak silkworms need about 4 ha of forest land to be able to survive.

From the time when silkworm farmers release oak silkworms on the mountain to the months of collecting cocoons, silkworm farmers need to go up the mountain almost every day. On the one hand, they prevent birds from eating silkworms. Basically, once birds fly over, the whole field of oak silkworms will be eaten up. On the other hand, they manually cut and move oak branches to release oak silkworms to trees with denser leaves. This requires silkworm farmers to walk 20 to 30 miles of mountain roads every day, not including the spreading of lime powder and spraying of liquid chemical product before the oak silkworms go up the mountain. The entire oak silkworm breeding includes indoor cultivation, silkworm transplanting, oak tree pruning (tussah silkworm groups are moved from one tree to another) and manual cocoon picking. Each link contains too much sweat and effort from silkworm farmers, which also seriously restricts the development of the oak silkworm industry. For oak silkworm farmers, how to use more new equipment to improve the production efficiency of this ancient industry and expand the scale of oak silkworm breeding has become a top priority.

Common insect pests of oak trees include the calico moth (also known as the black-headed oak caterpillar), whose larvae feed on oak leaves. When an outbreak occurs, they can eat up all the leaves, seriously affecting the growth and development of oak trees. In addition, there are pests such as the yellow palm boat moth, the yellow two-star boat moth, the thorn moth, and the weevil. Common diseases of oak trees include powdery mildew, brown spot disease, and dry disease.
The first round of chemical product for the prevention and control of oak diseases is completed in early April. Generally, lime powder can be spread for prevention and control, and the amount per hectare is about 225kg. The second round of insecticide is mainly used to target pests such as the calico moth and maggots. In the past, silkworm farmers often had to carry chemical product boxes on foot to spray oak trees. Manual spraying of the liquid could not cover the top of the oak canopy, and it was easy to cause poisoning. The use of agricultural drones to spray pesticides avoids direct contact between people and drugs. The droplets of the pesticide sprayed by drones are smaller in size and are more likely to adhere to the front and back of the oak leaves and the surface of the pests. With the strong downward pressure of the drone rotor, it can also disturb the oak leaves to help the liquid penetrate to the bottom area of the oak tree.

T50 agricultural drone is used to control diseases and insect pests for oak trees. Users generally use crosshairs to circle the land on the remote control and turn on omni-directional obstacle avoidance function in field route mode. Because oak trees in silkworm farms are basically planted on a slope with a height of 50-200 m, the slope is generally less than 35 degrees, so the operation scene needs to choose mountain / fruit tree mode to turn on the function of setting height and detour.
In addition, when the distance between oak trees is large, it is easy to trigger obstacle avoidance and the fixed height should be set at about 3-4m.
It should be noted that when the drone works on the back of the slope, the mountain is easy to block the remote control signal, so it is necessary to ensure that the remote control is at the commanding height of the hillside and is flat and open, or use 4G enhanced graphics transmission function

Model	T50	Flight Speed	5 m/s
Relative Crown Height	3-4 m	Operation Row Spacing	7 m
Volume	90-120 L/ha	Droplet Size	150-200 μm

In addition to spreading lime powder and spraying liquid chemical product, agricultural drones can also be used to help silkworm farmers transport silkworm baskets up and down the mountain. In the past, silkworm farmers need to carry silkworm baskets up and down the mountain frequently. With drones, more than 200 kilograms of silkworms can be transported up the mountain in just a few hours, greatly improving the efficiency of sericulture households.
Agricultural drones are changing the ancient industry of oak breeding with their unique advantages, helping silkworm farmers improve their efficiency, and then expand the scale of breeding and increase production and income.

Using T40 Drones to Spray Agave

Agave, a resilient desert plant, is central to the production of tequila, a beverage deeply rooted in Mexican culture. Predominantly cultivated in Jalisco, Mexico, particularly the Tequila region, agave farming has unique challenges and requirements. The region's arid climate and rocky terrain make traditional farming practices both labor-intensive and costly, especially for herbicide application, which is crucial for the proper development of young agave plants (1-3 years).

Proper herbicide application is essential but comes with several significant challenges:

Time Constraints: Herbicides need to be applied just before the rainy season, a narrow window during which farmers must cover extensive fields.

Labor Shortages: Manual spraying is labor-intensive and costly due to the expensive herbicides and the need for large labor forces. It can be difficult to hire sufficient labor, especially for larger agave farms.

Safety Concerns: Traditional methods expose workers to harmful chemicals, posing significant health risks.

Water Shortages: Water resources are limited, especially in remote areas where agave is grown.

Growing high-quality agave requires timely interventions, including herbicide application, fertilization, and pest control, across a 7-year growth cycle. Traditionally, these tasks are performed manually by large teams of laborers or by tractors, which is time-consuming, costly, and prone to human error.

Before the advent of drone technology, agave farmers relied on tractors with sprayers or manual backpack sprayers. These methods have several drawbacks:

Time-Consuming: Tractor spraying takes about 1 hour per hectare on average, while manual backpack spraying requires 1.5 hours per hectare with a team of 10 people.

High Water Consumption: Traditional manual or tractor spraying methods use significantly more water compared with drones. For agave, 200 L of water can be used for a single hectare.

High Costs: Traditional methods increase the cost per hectare by 42% to 55%. Manual labor requires large teams, takes a long time, and costs approximately $60 per hectare.

Safety Risks: Both tractor and manual backpack spraying expose operators to harmful chemicals, as well as the risk of injuries from traversing the rocky agave fields.

Limited Accessibility: The rocky and uneven terrain of agave plantations makes it challenging for tractors to operate, often resulting in inefficient coverage. Tractor usage, while more efficient in terms of time compared to manual spraying, could damage the agave plants and still incurred the same cost per hectare.

Our case study focuses on an agave producer in the Tequila region who began exploring DJI Agriculture drones about 10-14 months ago. Faced with the time constraints and high costs of traditional herbicide application methods, they decided to adopt DJI's Agras T40 drones during the 2023 wet season. With a team of two pilots, they have successfully treated approximately 300 hectares of agave fields so far.

Operation Workflow

Date and Time

The drone intervention took place on June 28, 2023, in Tequila, Mexico. The weather on the day of the intervention was favorable, although specific details on temperature, humidity, and wind speed were not recorded.

Drone Used

The chosen drone for this operation was the DJI Agras T40, selected for its larger capacity, allowing more terrain to be covered per flight. The P4 Multispectral drone was also selected for its mapping and sensing capabilities, which enhanced the efficiency of the spraying process.

Chemical Information

The herbicide used was Amvac Krovar, a combination of Bromacil and Diuron in dry granule form, diluted in water at a ratio of 3 kg per hectare. This solution applied at a ratio of 200 ml per hectare, significantly reducing the amount of water required compared to traditional methods.

Results

Immediate Outcomes

The results were evaluated one month after the intervention. Compared to untreated controls, the agave plants treated with the drone showed a significant improvement in health and growth, with a noticeable reduction in weed competition. When compared to plots treated manually or by tractor, the agave health appeared comparable, but this was achieved with significantly reduced operational costs and time:

Time Reduction: From 1 hour per hectare with a tractor to just 6 minutes with the drone, a reduction in operation time by 90-95%.

Environmental Benefits: Decreased water usage by 88%, from 250 L/ha with traditional methods down to 30 L/ha with drones.

Cost Savings:

Cost Breakdown	Drone Spraying	Tractor Spraying	Manual Spraying
Labor Costs	$1.43	$14.29	$57.14
Chemical Costs	$133.71	$133.71	$133.71
Fuel Costs	$0.00	$44.57	$0.00
Equipment Maintenance & Depreciation	$1.83	$1.83	$0.00
Other Costs	$2.86	$5.71	$26.74
Total Cost Per Hectare	$139.83	$200.11	$217.60

Method	Area Covered	Number of People	Time Taken
Manual Labor	1 hectare	10	90 minutes
Tractor	1 hectare	1-2	1 hour
Drone	6 hectares	3	1 hour

Benefits of DJI Drones

The DJI Agras T40 drones offered multiple benefits:

Efficiency: Time spent on herbicide application reduced tenfold.

Cost Savings: Lower operational costs due to reduced labor and chemical usage.

Safety: Minimized direct contact with harmful chemicals.

Environmental Impact: Water usage reduced from 250 liters per hectare to just 30 liters.

Testimony

Farmer's Satisfaction

"Using Agras T40 drones for herbicide spraying was not only a cost-effective solution that allowed us to make better use of our resources and personnel but also enabled us to complete our herbicide application schedule just before the rainy season began," said the agave producer. "This technology has revolutionized our approach to farming."

Conclusion

In summary, the integration of DJI Agras T40 drones in agave farming has demonstrated significant improvements in efficiency, cost savings, safety, and environmental sustainability. This case study is a testament to the transformative power of drone technology in agriculture, offering valuable insights for agricultural innovators, drone enthusiasts, and sustainable farming advocates.

Future investigations will proceed with the Agras T50 in order to determine how many tasks a drone can complete for an agave producer within one year.

The Agave farmer featured in this case concludes with this advice: "For those considering DJI Agriculture drones, start by understanding your specific needs and how drone technology can address them. The efficiency and cost savings are transformative."

Best Practices

The use of agricultural drones is a multi-directional combination of personnel technology, product technology development, agronomy, agricultural technology, and pesticide application. This is inseparable from the joint efforts of the entire industry and the continuous exploration of the formation of "best practices".

Personnel Training

In 2023, on the basis of existing training countries, DJI Academy continued to carry out instructor training, pilot training, smart agriculture training and orchard application training in Australia, Europe, the United States and South American countries to popularize knowledge and skills for more partners and users.

In 2024, DJI conducted team and content integration in training to provide more advanced training for partners combined with crop solutions, including pre-sales training for sales staff, delivery engineer training for technical personnel, so that partners can get a full range of product and industry education and promotion, so as to better serve the industry and users.

Figure 73 DJI Academy Training in Turkey

Technology Development

1. DJI Agras T50

The DJI Agras T50 is a flagship of efficiency and stability, born from a deep understanding of the demands of large-scale farming. It inherits a coaxial dual-rotor design and 54-inch propellers for next-level stability when carrying 40kg spraying or 50kg spreading payloads, which enables efficient spraying of up to 50 acres (21 hectares) per hour[16]. T50's dual atomization spraying system, with an increased flow rate of up to 16 liters per minute with two sprinklers and adjustable-sized spray droplets, is ideal for a variety of applications from fields to orchards. Easily converted to its spreading configuration, the T50 can carry 50 kg of dry granules and spread at a flow rate of up to 108 kg/min[17] or 1.5 tones per hour2. This combination of power, precision, and versatility sets T50 apart as a top choice in agricultural drones, designed to meet the evolving needs of modern farming.

T50 features an upgraded four-antenna O3 Transmission system, extending the remote controller-drone connection up to 2 km[18]. For operations over mountains and other complex environments, users can deploy a DJI Relay to extend transmission range and stability for improved operation safety.

Dual Radar and Dual Binocular Vision for Obstacle Bypassing and Terrain Following

T50 features dual Active Phased Array Radars and binocular vision sensors. These work together to accurately reconstruct the T50's surroundings and detect nearby obstacles, for intelligent obstacle sensing and bypassing, and Terrain Following over slopes.

T50 can be equipped with an additional pair of centrifugal sprinklers, increasing flow rate to 24 liters per minute. This benefits tasks like orchard spraying that require a higher flow rate to penetrate dense canopies and treat the fronts and backs of leaves.

T50 is powered by a DB1560 Intelligent Flight Battery, with a capacity of up to 30 Ah and 1500 charge cycles[19]. The D12000iEP Multifunctional Inverter Generator paired with the Air-Cooled Heat Sink enables 9-minutes[20] fast charging, allowing for continuous operations with a pair of batteries.

2. Agras T25

The Agras T25 packs all the advanced features of the T50 into a smaller, portable design. It can carry a 20 kg spraying or 25 kg spreading payload and includes the T50's top features like multidirectional obstacle avoidance, Terrain Following, ultra-fast battery charging, one-tap takeoffs, and automatic operations. This makes it perfect for solo use in small to medium-sized farms.

3. DJI SmartFarm - Essential Agras Assistant

The DJI SmartFarm App streamlines daily drone operations for crop protection and plot management with enhanced data visualization and reporting, a dynamic device management dashboard, and easy access to after sales support and learning resources on DJI Academy.

16. Data was measured with the DJI AGRAS T50 and may vary based on operating environment and parameters. Flight parameters for this test: Dosage of 15 L/ha, spraying width of 11 m, flight speed of 7 m/s, and height of 3 m.

17. Data measured with 4 mm diameter urea. Max flow rate may vary depending on the granule size, density, and surface smoothness of different fertilizers.

18. Measured at a flight altitude of 2.5 meters, without obstruction or electromagnetic interference.

19. Batteries are covered by warranty for up to 1,500 charging cycles or 12 months, whichever ends first.

20. Charging from 30% to 95%. Factors impacting charging time: Altitude of the charging station; Charging cable meets requirements for fast charging; Battery cell's temperature is in the range of 15° to 70° C (59° to 158° F)

Combination of Agronomy and Technology: Principles and Skills for Orchard Application

1. How to Select Parameters?

The three-dimensional routes in DJI Agricultural Orchard Solutions include: Distance Interval, Tree Crown Center, Semi-automatic, and Manual in DJI Terra; Field and Custom Route on DJI SmartFarm Web, and Standard, Targeted and Custom on the remote controller.

In order to simplify the article, the terms Distance Interval, Field, and Standard (hereinafter referred to as “Area Mode”) will be used throughout this chapter. The terms Semi-automatic, Manual, Custom Route, and Custom (hereinafter referred to as “Strip Mode”) will be used throughout this chapter.

Secondly, the route mode should be selected according to the planting density, type, age, distribution and topography of fruit trees and orchard.

In the following scenarios, Area Mode is suggested.
a. An orchard with high planting density (plant spacing ≤ 1 + crown diameter, row spacing ≤ 2 + crown diameter, similar to closed row), neat planting, no large canopy height difference and small slope.
b. The special operation requirements of fruit trees, such as orchard clearing, comprehensive prevention and control of large-scale outbreaks of diseases and pests, etc.
In the following scenarios, Strip Mode is suggested.
a. The planting density is small (large plant spacing and row spacing, that is, unclosed rows), and the planting trend of fruit trees is distributed with the contours of the mountain, etc.
b. For 1-2 years young trees with large gaps, pesticides could be saved by using Strip Mode.
Then, the operation parameters are selected according to the model of DJI AGRAS drone, the type of route, the object of application, weather factors (temperature, humidity, wind speed) and working time.

When using the Strip Mode, the flow rate and speed of the drone in operation are the main factors to be considered.
a. Flow Rate: The flow rate of fruit trees operation ranges from 4 to 20 L/min.
b. Speed: The operating speed of fruit trees operation ranges from 1 to 3 m/s, but the more turning of the route, the greater the speed loss, and the empirical coefficient is 0.925.

When using the Area Mode, the Application Rate and Route Spacing in the operation are the main factor to be considered.
a. Application Rate: The Application Rate in fruit tree operation range from 75-450 L/ha.
b. Route Spacing: The Route Spacing in fruit tree operation range from 3.5-5.5 m.

2. How to Calculate the Total Water Consumption

1) Area Mode

a. Area calculation method: the actual operating area is calculated by Route spacing and route length in orchards with small slope; and the oblique width of the spacing and route length are used in orchards with large slopes.
b. Calculation: actual coverage area of the route (Hectare) × volume (L / Hectare) = total water consumption (L).
c. Area in the Area Mode ≈ actual coverage area of the route = field length × route spacing × number of the lines.
d. The projected area and surface area could be selected in orchard with small slope, and the total water consumption is roughly the same
e. Surface Area should be selected in orchard with large slopes, and the total water consumption is relatively accurate.

2) Strip Mode

a. Calculation: [route length (m) / speed (m / s) × 0.925 / 60] × flow rate (L / min) = total water consumption (L).
b. Actual coverage area of Strip route = route length × (crown diameter + 1 meter)

Detailed Explanation of Incorrect Application

The application of agricultural drones involves flight safety and pesticide safety. In order to help practitioners apply pesticides more safely, some detailed explanations of application errors are provided here.

Mistake 1
Spraying Herbicides in Unsuitable Areas such as Downwind, Near Sensitive Crops, etc.

Many chemical products have certain drift characteristics, especially herbicide products. Therefore, when spraying selective herbicides, we should pay attention to the existence of sensitive crops around to avoid drift damage and affect the growth of crops around.

For example, in winter, both winter wheat and rapeseed exist on the cultivated land. If weeding is being carried out on wheat and the rapeseed area is downwind of the operation area, the herbicide may drift to the rapeseed area and cause the death of the rapeseed.

Mistake 2
Spraying Insecticide Near Bees and Mulberry Trees

Chemical pesticides have a certain impact on the activity of bees. In particular, the widely used neonicotinoid insecticides (imidacloprid, thiamethoxam, etc.) have a strong killing effect on bees, and special attention should be paid to whether there are bee breeding activities around the spraying of such pesticides. Other pesticides should also be formulated according to the product label requirements to confirm the degree of impact on bees before formulating the application plan and the window for releasing bees.

In areas where there is a bee breeding industry, before the operation, the person in charge of the cultivated land should confirm in advance whether there is bee breeding within 3 kilometers around. If there is, the operation cannot be carried out. Or confirm with the bee breeder and transfer the bees in advance before the operation.

For areas where mulberry trees are planted downwind, it is strictly forbidden to spray pesticides.

Mistake 3
Spraying Herbicides on Stems and Leaves of Corn

Common corn herbicides include Atrazine and Nicosulfuron, both of which are safe for corn but unsafe for other crops, so corn weeding operations should be particularly cautious.

Drift damage to corn weeding often occurs in the following situations:

a. The height is too high, and in some cases, the height even reached 5 meters;

b. Droplets below 100 μm were selected, which increased the distance of droplet drift;

c. There are other crops within 100 meters downwind of corn, and the environmental wind force during operation is above level 3, which increases the drift distance.

Mistake 4
Use High Speed or Coarse Droplets for Orchard Operations.

Orchard have the characteristics of high plant height, thick canopy and difficult to penetrate, so the selection of operation parameters should adhere to the principle of higher water volume, low speed and finer droplets. The faster the speed of agricultural drones, the worse the penetration of droplets into crops. The common speed is generally around 1.5-3 m/s.

Some service provider who often operate in crop fields do not know the specific parameter of orchard operations. They use the common 15-30 L/ha and 6-7 m/s in field operations. Such operations have poor results and are not conducive to subsequent commercial promotion.

At the same time, fruit trees are lush and need more droplets to improve the operation effect, so finer droplets should be selected. For models such as T20/T30 with standard pressure spraying system, standard nozzles should be selected, and it is not recommended to replace nozzles. For models such as T50/T40 with centrifugal nozzles, the droplet size can be adjusted to fine size.

There are many electric wires in some areas, and some pilots fly directly to a height of more than ten meters for safer flight. After the liquid chemical product is sprayed, it takes several seconds to reach the surface of the crop. If the ambient temperature is high and the wind speed is high, this operation method will cause a large amount of liquid chemical product to evaporate and drift with the wind. In the end, most of the chemical product cannot effectively reach the target.

Epilogue

Agricultural drones, as high-tech and new productivity, have injected new vitality into agriculture, which has lasted for tens of thousands of years. The development of the agricultural drone industry represents people's yearning for a healthy and beautiful life, and also represents people's down-to-earth commitment to agriculture.
In the new year, we hope that the agricultural drone industry will continue to work together to improve production efficiency and protect the ecological environment, making agriculture easier and life better.