Reforestation using Agricultural Drones and FPV Drones in the Heights of Veracruz. A Contribution of CONALEP II Veracruz and TECNM Campus Veracruz to the Reforestation of Hills Affected by Forest Fires

Víctor Manuel de Jesús Leyva Negrete
Institución: Tecnológico Nacional de México (TECNM) - campus Veracruz
Máster en Ciencias de la Educación
Dirección: Av. Miguel Angel de Quevedo, 2779, Formando Hogar, 91897 Veracruz, Ver., México

Cuitláhuac García Jiménez
Institución: Universidad Técnica de Hamburgo-Harburg
Doctor en Ingeniería
Dirección: Av. Miguel Angel de Quevedo, 2779, Formando Hogar, 91897 Veracruz, Ver., México

Miguel Ángel Quiroz García
Institución: Tecnológico Nacional de México (TECNM) - campus Veracruz
Doctor en Ciencias Pedagógicas
Dirección: Av. Miguel Angel de Quevedo, 2779, Formando Hogar, 91897 Veracruz, Ver., México

Leodegario Vázquez González
Institución: Tecnológico Nacional de México (TECNM) - campus Veracruz
Máster en Energías Renovables
Dirección: Av. Miguel Angel de Quevedo, 2779, Formando Hogar, 91897 Veracruz, Ver., México

Ivonne Ramírez Gutiérrez
Institución: Universidad Cristóbal Colón
Máster en Educación
Dirección: Av. Miguel Angel de Quevedo, 2779, Formando Hogar, 91897 Veracruz, Ver., México

Edith Martínez Leo
Institución: Universidad Popular Autónoma de Veracruz
Licenciada en Ingeniera Mecatrónica
Dirección: Guillermo Prieto #8, Col. 2 de abril, Xalapa-Enríquez, Ver

Valeria Palacios Cruz
Institución: Tecnológico Nacional de México (TECNM) - campus Veracruz
Est. Ingeniería Electrónica
Dirección: Av. Miguel Angel de Quevedo, 2779, Formando Hogar, 91897 Veracruz, Ver., México

DOI: https://doi.org/10.56293/IJASR.2024.6202

IJASR 2024
VOLUME 7
ISSUE 6 NOVEMBER – DECEMBER **ISSN: 2581-7876**

Abstract: Climate change has increased the incidence of forest fires in the Mexican Republic in the years 2023 and 2024 [1]. The areas affected by forest fires represent a great challenge for their reforestation with endemic species, especially in mountainous terrain with steep slopes or difficult-to-access ravines [2]. This article presents an innovative approach that uses agricultural drones and high-speed FPV drones to carry out seed sowing in affected areas of Maltrata, El Llanillo and the peaks of Acultzingo, Veracruz, where more than 40 hectares have been reforested with various species of native plants. FPV drones, capable of reaching elevated areas of up to 320 meters and distances of more than one kilometer, allow covering land that would be inaccessible to traditional agricultural drones. The results show a dispersal rate of 1 kg of seeds per hectare and a reforestation capacity of approximately 25 to 40 hectares per hour. This technological approach has proven to be efficient and sustainable in restoring ecosystems damaged by fire.

Keywords: Reforestation, drones, sowing, ecosystem

1.- Introduction

In the mountainous areas of the state of Veracruz, forest fires have devastated large areas, affecting both plant and animal life. Figure 1 shows the fire that occurred in March 2024 in the Maltrata area. Reforestation efforts are limited by the difficult access to these areas, especially in regions such as the summits of Maltrata,

El Llanillo and Acultzingo. The use of drones has opened new possibilities to overcome these obstacles, allowing reforestation in hard-to-reach areas. The proposed methodology combines the use of agricultural drones and high-speed FPV drones, which has allowed planting on land with altitudes of up to 320 meters and distances of more than one kilometer from the nearest access point.

Figure 1. Fire in the peaks of Maltrata.
Fuente: https://heraldodemexico.com.mx/nacional/2024/3/24/-incendio-en-las-cumbres-de-maltrata-veracruz--588473.html

Figure 2. Fire in the peaks of Maltrata.
Fuente: https://www.wikiloc.com/hiking-trails/el-llanillo-valle-alegre-77825216

2.- Methodology

The Secretariat of the Environment (SEDEMA) identified the areas affected by forest fires in 2024[4] Maltrata, El Llanillo and Acultzingo, where topographic and access analyses were carried out. identifying areas that are difficult to access for reforestation brigades due to the rugged topography, a possible accesss solution is to do so with drone dispersion technology. Figure 2 shows some of the areas selected for reforestation.

3.- Drone dispersion method.

Agricultural drones have their main application in spraying and fertilizer dispersion systems [4] with the disadvantage of having a high cost. To reduce the economic impact, teachers and students selected the elements of the drones to build them. Regarding the dispersion method, it was designed with the Blender 3D program. Figure 3 shows the final design and Figure 4 shows the implementation of the system.

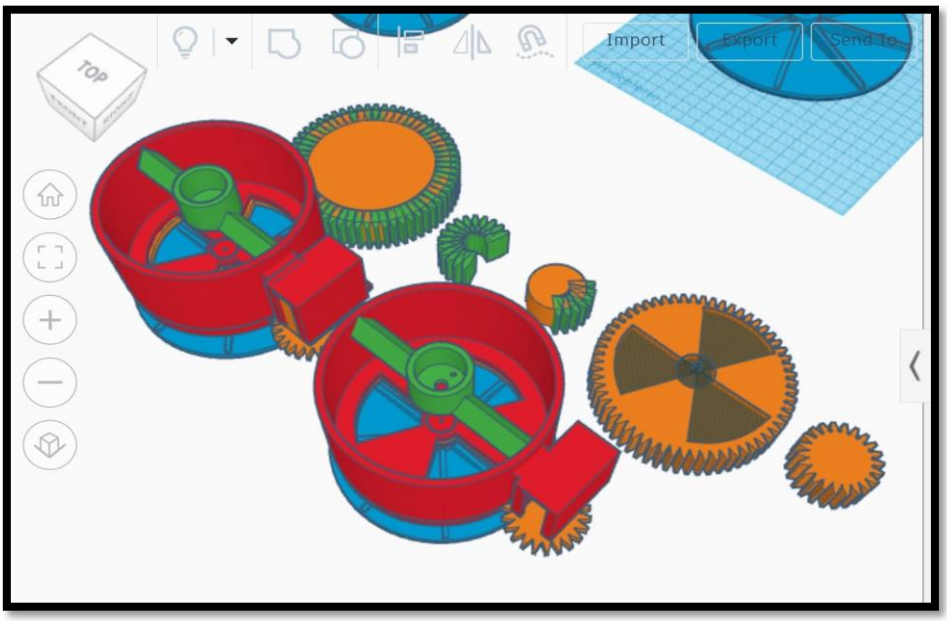

Figure 3. Seed dispersal system design.
Source: Own photograph of the process

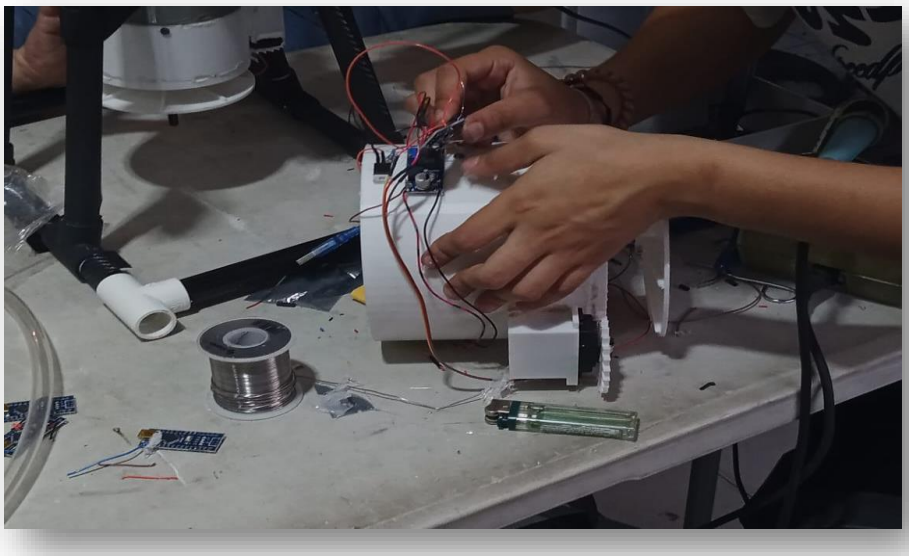

Figure 4. Implementation of the seed dispersal system.
Source: Own photograph of the process

4.- Selection and construction of drones.

From the information provided by SEDEMA it can be deduced that there are plain areas and areas with mountains and ravines. For the plain area, the adaptation of drone technology used in dispersing fertilizers was chosen; hexacopter-type drones have a load capacity of up to 20 kilos. Figure 5 shows the area designated by SEDEMA for dispersion with agricultural drones

Figure 5. Llanillo Redondo property. Municipality of Las Vigas
Source: https://en.mexico.pueblosamerica.com/i/el-llanillo-redondo/

Figure 6. Dispersion in the Llanillo Redondo Property. Municipality of Las Vigas
Source: Own photograph of the process

The hexacopter drone uses 12S 16,000 mAh batteries, which allows it to fly for more than 10 minutes, covering up to 4 hectares per flight. The consumption in flight is 100 amps, with peaks of 160 amps at elevation. By unifying the seed dispersion system with the drone, a sowing system is achieved that allows covering large areas of flat land.

Figure 6 shows the implementation of the system in the sowing area
Figure 7. Dispersion Property: Cerro del Xochio, Tecamalucan locality, Acultzingo municipality
Source: https://mapcarta.com/es/19378052

The Acatzingo area has areas with steep ascending slopes with heights greater than 30 meters. SEDEMA designated this area for reforestation with drones. Figure 7 shows the area designated by SEDEMA.

In this area, it was decided to use drones with FPV technology that use 6S and 8S batteries for these drones, with a duration of 4 to 8 minutes per flight, which allows 2 to 4 trips with a payload of 1.5 kg. At a speed of 80 km/h, FPV drones can cover 3 to 6 hectares per flight. The average consumption is 30 amps in flight, with peaks of 65 amps during elevation. The design is a quadcopter type with double motor per arm, reaching a maximum thrust of 10 kg, allowing to reach areas that are impossible to reach with reforestation personnel. Figure 8 shows the implementation of the FPV system.

Figure 8. Implementation of the seed dispersal system.
Source: Own photograph of the process

5.- Results

A total of 45.5 hectares were reforested with native species, including oaks and grasses. The planting density was approximately 1 kilogram of seeds per hectare. The planting areas are shown in Table 1.

Table 1. Drone sowing area

Municipio	Localidad	Predio	Coordenadas y msnm	Liga	Superficie (ha)	Cantidad "Kg"	Especies	Fecha
Perote	Los Molinos	Cerro de la Paloma	19.593138° / -97.175757° 2,595 msnm	https://maps.app.goo.gl/Sumu3oENxniCc2y76	3	2.5	*Pinus patula, P. pseudostrobus y P. montezumae.*	Jueves 22 09:00
Las Vigas	El Llanillo	El Llanillo	19.558223° / -97.107763° 1,800 msnm	https://maps.app.goo.gl/bMxEuuuGCPd1BhQ59	4	3	*Pinus teocote, P. pseudostrobus y P. montezumae.*	Viernes 23 09:00
Acultzingo	Tecamalucan	Cerro del Xochío	18°46'31.42"N -97°14'43.31"O (1,587 msnm)	https://maps.app.goo.gl/tnt38arSxGgrmMk6A	16.5	10	*Encinos, Capulín, Veza de Invierno, Huizaches, Lupinus y gramíneas*	Jueves 29 de agosto. 08:00 hrs
Maltrata	El Caliche	El Caliche	18°48'47.62"N, -97°15'12.10"O (1,739 msnm)	https://maps.app.goo.gl/SPV9gf2aZmQi8LTW6	22	12	*Encinos, Capulín, Veza de Invierno, Huizache, lupinus y gramíneas*	Viernes 30 de Agosto. 08:00 hrs

The reforestation capacity was 5 hectares per hour using high-speed FPV drones and agricultural drones. In the Maltrata summit area, it was possible to cover areas located 320 meters high and at a distance of 1 kilometer from the nearest access point, which would be impossible with traditional agricultural drones.

The agricultural drones, programmed to fly autonomously using GPS-traced routes with data provided by SEDEMA, managed to cover more accessible areas efficiently.

6.- Conclusions

The use of FPV drones has been key to overcoming the limitations imposed by the terrain in these mountainous areas with steep upward slopes of more than 50 meters reaching heights of 320 meters impossible to reach with traditional agricultural drones. Reforestation using drones, particularly the use of high-speed FPV drones, has proven to be an innovative and effective solution for the restoration of ecosystems in mountainous areas affected by forest fires. The results obtained in Maltrata, El Llanillo and Acultzingo underline the capacity of this technology to face challenges of access and altitude, allowing the regeneration of more than 40 hectares in a short period of time. It is advisable to visit the reforested areas in the following years to evaluate the germination of the germplasm with this sowing technique to assess its effectiveness with traditional methods.

7.- Bibliographic references

1. Conagua. (s.f.). *Gobierno de México*. Obtenido de https://smn.conagua.gob.mx/es/alertamientos/105.html
2. https://www.veracruz.gob.mx/2019/11/20/imparte-sedema-29-talleres-sobre-reforestacion-de-bosques-y-selvas/
3. https://heraldodemexico.com.mx/nacional/2024/3/24/las-imagenes-del-terrible-incendio-en-las-cumbres-de-maltrata-veracruz-vecinos-piden-ayuda-588473.html
4. https://www.sedema.cdmx.gob.mx/comunicacion/nota/iniciara-sedema-jornadas-de-reforestacion-en-las-barrancas-guadalupe-mixcoac-tarango-y-echanove
5. Uso de los Drones o Vehículos Aéreos no Tripulados en la Agricultura de Precisión Revista Ingeniería Agrícola, vol. 11, núm. 4, e10, 2021 Instituto de Investigaciones de Ingeniería Agrícola