

Research Article

**Application and comparative study of Unmanned Aerial Vehicle
for spraying insecticide in Sugarcane crop**

Vishnu J. Gaikwad^{1*} and H.D.C De Silva²

¹Tatyasaheb Kore Institute of Engineering and Technology,
Warananagar, Kolhapur, India

²Faculty of Agriculture, University of Ruhuna, Mapalana,
Kamburupitiya, Sri Lanka

*vishnu.gaikwad@gmail.com

[Received 01 Aug-2023, Accepted 03 Sept-2023, Published 05 Sept -2023]

Abstract

It's very challenging part in Indian agriculture to accept the modern techniques, because of its cost and availability. The ministry of Indian government taking active part in this regards the subsidy for farmers are announced upto 50%-100% to purchase the UAVs. Application of UAVs has not only reduced the time and efforts of the farmers but also increased profitability. This step of Indian government is very precious for the farmers to implement the new techniques in agriculture.

Scientific studies are carried out and data supporting the drone application are generated. The major population of Latur district is primarily agricultural. Urban population comprises 25.47% of the total population. This paper presents a use of drone technology and their applications in the agriculture sector in like sugarcane crop. The application of drones in the area of crop pesticide spraying has been covered. We have discovered the application of UAVs for spraying is cheaper than the conventional and spraying using tractor. Regarding the important variable is Time, 8 hours per hecter in traditional method and 5 hours for spraying using the tractor and we required 2.5 hours per hecter in UAV/drone spraying. In present study, collectively we conclude that the new era adopting in agriculture, use of UAVs/drones are very precise to time, money saving and has a great future ahead.

Keywords: Unmanned Aerial Vehicles, drone, Tractor Sprayer, traditional Sprayer, insecticide, Sugarcane

Introduction:

Present agricultural era, farmers are able to use high-tech sensing devices based on GPS, remote sensing, as well as farm management software which brings revolutionary changes into farming, to optimize both farm productivity and profitability based on real-time field information thus protecting the environment.

Scientific studies are carried out and data supporting the drone application are generated.

Pilot studies with different approaches like use of remote sensing technology including satellite data and drone based images especially for crop cutting experiments planning, direct yield estimation at Gram Panchayat level, risk mapping of district and for dispute/area discrepancy resolution etc. have been conducted through Mahalanobis National Crop Forecasting Centre (MNCFC).[1]

Drones, or unmanned aerial vehicles (UAVs), are gaining momentum as transformative technology in the realm of disaster medicine and prehospital care delivery [2]. Their multifaceted capabilities, ranging from aerial surveillance to medical supply delivery, are redefining the paradigms of emergency response in disaster-stricken regions [2,3].

Disasters, both natural and manmade, often entail complex situations that require swift and efficient management to mitigate human suffering. For instance, floods and earthquakes can lead to significant casualties and damage to infrastructure, thereby impeding the traditional means of emergency response. Drones, with their advanced technological capabilities, have shown promise in these challenging environments [4-7].

In search and rescue operations, drones can play a pivotal role in identifying and locating individuals trapped in disaster-stricken areas. Advanced drones are equipped with thermal imaging and infrared sensors that can detect heat signatures from human bodies, even under debris or in low-light conditions, thereby aiding the identification of trapped or injured individuals during earthquakes or building collapses [8,9]. The primary aim of the system is to deploy a fully autonomous mechanism which will be able to spray specific areas with high accuracy and without any human intervention.[10]

Gurtner et al. [11] investigated the use of fish-eye lenses to overcome field-of-view (FOV) issues for highly agile UAV platforms susceptible to turbulence and explained the benefits of a FOV in terms of the large observation area and less aircraft weight. The effectiveness of the image matching algorithms, Scale-Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) over a set of aerial images from an Unmanned Aerial Vehicle (UAV) is evaluated and compared [12]. Experimental results show the robustness of image matching over different camera perspectives, angles, and positions, encouraging the use of computer vision methods for UAV navigation.

Sebastian et al. [13] presented the application of an Unmanned Aerial Vehicle (UAV) for monitoring soil erosion in Morocco. The authors successfully performed the data acquisition at multiple scales, closing the gap between field and satellite image scales with the chosen fixed-wing UAV. Cheng et al. [14]

There are number of studies that have discussed emerging trends in the development of agriculture 4.0 by providing succinct information on key applications, advantages, and corresponding research challenges of smart farming [15-24].

Here is some Common applications of UAV are as follows;

1. Spraying of Fertilizer/Insecticides
2. Monitoring the soil health
3. Seeding process
4. Examining the flaws
5. Drones for fertilizing crops

Benefits of applications of UAVs;

- Great for monitoring and sensing techniques because they can quickly cover territory to check crop development and soil health.
- To keep crops healthy by dispersing water, fertilizer, and pesticides.
- Can stitch thermo graphic photos together over time to detect the direction of water flow and locate geographical features that may affect water dispersion.
- They can operate as mechanical pollinators.
- Use of drones for agricultural research. Drones can cover broad areas damaged by natural catastrophes to find the reasons and implications of incidents, from infections to insurance claims.
- Claims in agricultural insurance surveys.

Study Location:

We have selected the own agriculture farm for this study which is located in Latur district, in Ashta Village of Maharashtra State, India. The major population of latur district is primarily agricultural. Urban population comprises

25.47% of the total population. Latur District is bound by Nanded District to the northeast; the state border with Karnataka to the east and southeast; Osmanabad District to the south-

west; Beed District to the west; and Parbhani District to the northwest.[25] Applications of UAVs are represented in fig1.



Fig1: Applications of UAVs in agriculture

Through this analysis, we aim to better understand the geographic distribution of scholars who contribute to the applications of drones in agriculture. It is noteworthy to notice the diversity of countries and academic institutions. From a country perspective, the USA, China, India, and Italy rank at the top of the list in terms of the number of publications (Table 1).[26]

Rank	Countries
1	USA
2	China
3	India
4	Italy
5	Spain
6	Germany
7	Brazil
8	Australia
9	Japan
10	United Kingdom
Rank	Universities/ Organizations
1	Chinese Academy of Sciences
2	Ministry of Agriculture of the People's Republic of China
3	Consejo Superior de Investigaciones Científicas
4	Texas A&M University
5	China Agricultural University
6	USDA Agricultural Research Service
7	CSIC - Instituto de Agricultura Sostenible IAS
8	Purdue University
9	Consiglio Nazionale delle Ricerche
10	South China Agricultural University

Table1: Top most productive countries and universities/organizations that contribute to agricultural drone-related research.[26]

The manual mechanical sprayer is the most common tool for conventional pesticide

application. Manual spraying of the pesticides affects human beings and may lead to diseases

like cancer, hypersensitivity, asthma, and other disorders [27]. Additionally, conventional methods have several other shortcomings such as extra chemicals use, farm labour shortage, lower spray uniformity, environmental pollution, and less area coverage. These conventional methods cause a higher cost of pesticide application and are less effective in controlling pests and diseases. To overcome these shortcomings, a drone-mounted sprayer is being employed. The application of drone-mounted sprayers in the field has enhanced the coverage ability, increased the chemical effectiveness, and made the spraying job easier and faster.

First UAV (unmanned helicopter) for pesticides application was developed by Yamaha Motor Co. Ltd., Shizuoka Japan in 1983. The spraying volume should be based on the amount of pesticide required by crop biomass per unit volume rather than the land area size per unit. Leaf area index and vegetation biomass are characteristic parameters of crop growth status information, which can use as an essential basis for controlling the amount of pesticide spraying. At the same spraying rate, crops with

different leaf area indices had different droplet deposition results. The pre-experimental data showed that the deposition had a significant coefficient of variation [28]. A review [29] and numerous original full-text articles [30-35] focusing on aircraft systems for remotely monitoring and in-field management explicitly for sugarcane are available from the regular academic literature. We are used to spray the sugarcane crop as the cultivation is higher than other crop in our geographical area of Latur district.

Materials and Methods

A field experiment was conducted during 2020-2022 at Ashta, Latur, Maharashtra state, India.

In 2020-2021 the traditional spraying experiment was done, in 2021-2022 the experiment of spraying was done by using Tractor and the UAV (Drone).

We had taken the geographical outline from the district Bhumiabhilekh (Land Records and Revenue department), Chakur (Fig2). We had also taken the permission of spraying from the Sarpanch of Grampanchayat office of our village.

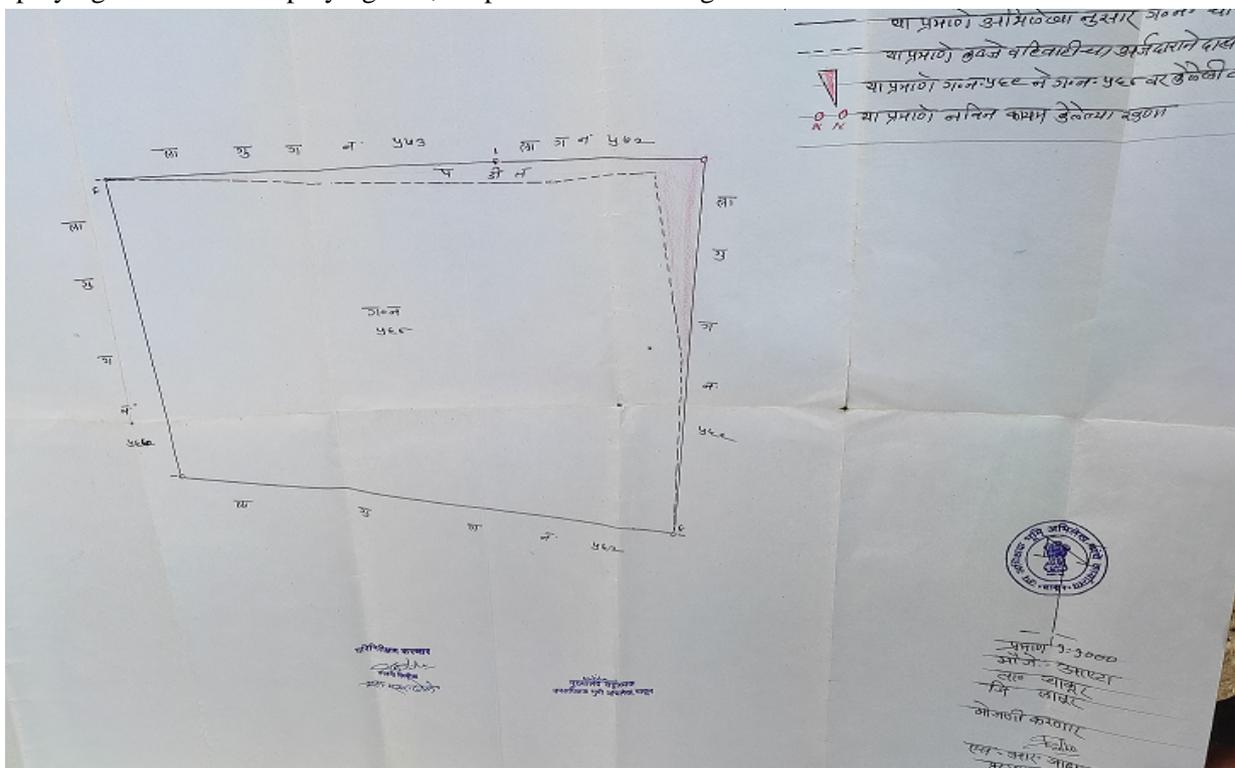


Fig2. Geographical outline from the district Bhumiabhilekh (Land Records and Revenue department), Chakur of Gat Number 568, in Ashta, Maharashtra State.



Figure3. Study area/Location.

Materials and Methods:

In present study we have applied the prototype Four-wheel-drive (4WD) drone having RGB camera (Multispectral camera), and laser+ Rotary-Wing to spray the cultivated farm and analyze its effectiveness. Drone is capable of carrying up to 10-liter pesticide tank and follow pre-mapped routes to spray crops according to the requirements. In this comparative study of the traditional spraying, tractor using spraying compared with the variables like the spraying time, chemical, water, manpower, accuracy. The research had done in Latur district of state of Maharashtra, Gat No: 568 in village ASHTA. The drone which we used in present study was characterised by the following features: a) 30 min maximum flight duration, b) 5 m/s average speed, c) 1000 m maximum flight altitude and d) 10 lit maximum supported weight.

The drone was hired from the Maharashtra based private agriculture company Nalegaon farmer Producer Company, located at Nalegaon, Maharashtra India. The spraying rate was cheaper and time saving technique for the farmers. We have applied the spraying the insecticide on sugarcane crop by using the drone.

The tree was 8 months old from plantation. The tree height ranged from 2.7 to 3 m, the planting density was 1,5000 plants/ha, Avg.

Leaf Area Index (LAI) is 2.8m . The flight height is ranged 2 meter above the sugarcane i. e. 5m from ground. The spraying done when low wind speed and the direction of spraying not affects. Uniformity of the spraying the insecticides on the sugarcane crom catagorized in lower, middle and higher. Uniformity observed is the percentage of the insecticide present on the crop i.e. lower=56-65%, Middle=70-75 and Higher= 90-95%



Fig 4a



Fig4a-b: Operational field photograph of sugarcane and UAV application.

Results and conclusion:

required 2.5 hours per hector in UAV/drone

variables	Traditional	Using Tractor Spryer	Drone
Insecticides Spraying (Lit/ha)	2.0	5.0	0.5
Water (Lit/ha)	500	1000	250
Time (hrs/ha)	8	5	2.5
Expenditure (INR/ha)	7000	7000	3500
spray uniformity	Lower	Middle	Higher
Labour(s) (Nos)	6	6	2

Table2: The compared results of Traditional spraying, Tractor using spraying and Using UAVs.

It's very challenging part in Indian agriculture to accept the modern techniques, because of its cost and availability. The ministry of Indian government taking active part in this regards the subsidy for farmers are announced upto 50% to purchase the UAVs. Application of UAVs has not only reduced the time and efforts of the farmers but also increased profitability. This step of Indian government is very precious for the farmers to implement the new techniques in agriculture.

As per the results obtained are very surprising, the insecticide which was used in our study, suggested the 4ml per litre in traditional method and 5ml/lit for spraying using the tractor and we have used 2ml/lit in UAV/drone spraying. Observed in present study, Insecticide required 2.0 litres in traditional method and 5.0 litres for spraying using the tractor and 0.5 litres in UAV/drone spraying. Use of water the 500ml per hector in traditional method and 1000 lit/ha for spraying using the tractor and we have used 250 litres in UAV/drone spraying.

Regarding the important variable is Time, 8 hours per hector in traditional method and 5 hours for spraying using the tractor and we

spraying.

The expenditure also surprising results like, INR 7000 per hector in traditional method and INR 7000 For spraying using the tractor and we required INR 3500 per hector in UAV/drone spraying.

Uniformity in spraying, lower in traditional method and middle for spraying using the tractor and we observed higher in UAV/drone spraying. Also the neighbour requirement is 6 in traditional method and for spraying using the tractor and we required only 2 labours in UAV/drone spraying.

In present study, collectively we conclude that the new era adopting in agriculture, use of UAVs/drones are very precise to time, money saving and has a great future ahead.

Limitations

Weather conditions, such as the change of the wind speed storm and rain, thus resulting in various damages and disasters like the environment pollution, not sprayed regions and possible economic failures due to the pesticides overlapping.

Battery, Another hurdle for UAV/drone operation is limited battery life. The power/electricity connection/ extra battery backup should be available at the locality where the operation of UAVs carried out.

Author Contributions

All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Informed Consent Statement

Not applicable.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments

The authors would like to extend their appreciation to Nalegaon farmer Producer Company for availability of UAV/drone for this entire research.

Conflicts of Interest

The authors declare no conflict of interest.

Abbreviations

Unmanned aerial vehicles (UAVs)
Leaf Area Index (LAI)
Mahalanobis National Crop Forecasting Centre (MNCFC)
Scale-Invariant Feature Transform (SIFT)
Speeded Up Robust Features (SURF)
Field-of-view (FOV)
Four-wheel-drive (4WD)
INR Indian Rupees

References

1. <https://pib.gov.in/PressReleasePage.aspx?PRID=1884233>
2. Pulver, A.; Wei, R.; Mann, C. Locating AED enabled medical drones to enhance cardiac arrest response times. *Prehosp. Emerg. Care* **2016**, *20*, 378–389. [Google Scholar] [CrossRef] [PubMed]
3. Claesson, A.; Bäckman, A.; Ringh, M.; Svensson, L.; Nordberg, P.; Djärv, T.; Hollenberg, J. Time to delivery of an automated external defibrillator using a drone for simulated out-of-hospital cardiac arrests vs. emergency medical services. *JAMA* **2017**, *317*, 2332–2334. [Google Scholar] [CrossRef] [PubMed]
4. Haidari, L.A.; Brown, S.T.; Ferguson, M.; Bancroft, E.; Spiker, M.; Wilcox, A.; Ambikapathi, R.; Sampath, V.; Connor, D.L.; Lee, B.Y. The economic and operational value of using drones to transport vaccines. *Vaccine* **2016**, *34*, 4062–4067. [Google Scholar] [CrossRef] [PubMed]
5. Casbeer, D.W.; Kingston, D.B.; Beard, R.W.; McLain, T.W. Cooperative forest fire surveillance using a team of small unmanned air vehicles. *Int. J. Syst. Sci.* **2006**, *37*, 351–360. [Google Scholar] [CrossRef]
6. Dorfling, J.; Siewert, S.B.; Bruder, S.; Aranzazu-Suescun, C.; Rocha, K.; Landon, P.D.; Bondar, G.; Pederson, T.; Le, C.; Mangar, R.; et al. Satellite, Aerial, and Ground Sensor Fusion Experiment for Management of Elephants and Rhinos and Poaching Prevention. In Proceedings of the AIAA SCITECH 2022 Forum, San Diego, CA, USA, 3–7 January 2022; p. 1270. [Google Scholar]
7. Meier, P. *Digital Humanitarians: How Big Data Is Changing the Face of Humanitarian Response*; CRC Press: Boca Raton, FL, USA, 2015. [Google Scholar]
8. Rajan, J.; Shriwastav, S.; Kashyap, A.; Ratnoo, A.; Ghose, D. Disaster management using unmanned aerial vehicles. In *Unmanned Aerial Systems*; Academic Press: Cambridge, MA, USA, 2021; pp. 129–155. [Google Scholar]
9. De Cubber, G.; Doroftei, D.; Roda, R.; Silva, E.; Ourevitch, S.; Matos, A.; Berns, K.; Serrano, D.; Sanchez, J.; Bedkowski, J.; et al. Chapter Introduction to the Use of Robotic Tools for Search and Rescue; InTechOpen: Rijeka, Croatia, 2017. [Google Scholar]
10. B. Dai, Y. He, F. Gu, L. Yang, J. Han, W. Xu, 2017. A vision-based autonomous aerial spray system for precision agriculture. *IEEE International Conference*

- on Robotics and Biomimetics (ROBIO) (2017), pp. 507-513,
11. GURTNER A., GREER D. G., GLASSOCK R., MEJIAS L., WALKER R. A., and BOLES W. W. Investigation of Fish-Eye Lenses for Small-UAV Aerial Photography. *IEEE Transactions on Geoscience and Remote Sensing*, 2009, 47(3): 709-721. <https://doi.org/10.1109/TGRS.2008.2009763>
 12. RODRIGUES R. C. B., and PELLEGRINO S. R. M. An Experimental Evaluation of Algorithms for Aerial Image Matching. *Proceedings of the 17th International Conference on Systems, Signals and Image Processing*, Rio de Janeiro, 2010, pp. 416-419. http://www2.ic.uff.br/iwssip2010/Proceedings/nav/papers/paper_130.pdf
 13. D'OLEIRE-OLTMANN S., MARZOLFF I., PETER K. D., and RIES J. B. Unmanned Aerial Vehicle (UAV) for Monitoring Soil Erosion in Morocco. *Remote Sensing*, 2012, 4(11): 3390-3416. <https://doi.org/10.3390/rs4113390>
 14. [44] LI Y.-C., YE D.-M., DING X.-B., TENG C.-S., WANG G.-H., and LI T.-H. UAV Aerial Photography Technology in Island Topographic Mapping. *Proceedings of the International Symposium on Image and Data Fusion*, 2011, pp. 1-4. <https://ieeexplore.ieee.org/xpl/conhome/6024198/proceeding>
 15. Y Liu, X Ma, L Shu, GP Hancke, AM. Abu-Mahfouz 0: Current Status, Enabling Technologies, and Research Challenges *IEEE Trans Ind Informatics*, 17 (2021), pp. 4322-4334, 10.1109/TII.2020.3003910 View in Scopus Google Scholar
 16. F da Silveira, FH Lermen, FG. Amaral An overview of agriculture 4.0 development: Systematic review of descriptions, technologies, barriers, advantages, and disadvantages *Comput Electron Agric*, 189 (2021), Article 106405, 10.1016/J.COMPAG.2021.106405 View PDFView articleView in ScopusGoogle Scholar[11]
 17. G Idoje, T Dagiuklas, M. Iqbal Survey for smart farming technologies: Challenges and issues *Comput Electr Eng*, 92 (2021), Article 107104, 10.1016/J.COMPELECENG.2021.107104 View PDFView articleView in ScopusGoogle Scholar[12]
 18. J Miranda, P Ponce, A Molina, P. Wright Sensing, smart and sustainable technologies for Agri-Food 4.0 *Comput Ind*, 108 (2019), pp. 21-36, 10.1016/J.COMPIND.2019.02.002 View PDFView articleView in ScopusGoogle Scholar[13]
 19. M Lezoche, H Panetto, J Kacprzyk, JE Hernandez Alemany Díaz MME. Agri-food 4.0: A survey of the supply chains and technologies for the future agriculture *Comput Ind*, 117 (2020), Article 103187, 10.1016/J.COMPIND.2020.103187 View PDFView articleView in ScopusGoogle Scholar
 20. Bhakta I, Phadikar S, Majumder K. State-of-the-art technologies in precision agriculture: a systematic review 2019. <https://doi.org/10.1002/jsfa.9693>. Google Scholar
 21. SO Araújo, RS Peres, J Barata, F Lidon, JC. Ramalho Characterising the Agriculture 4.0 Landscape—Emerging Trends, Challenges and Opportunities *Agron*, 11 (2021), p. 667, 10.3390/AGRONOMY11040667 Page2021;11:667 View in Scopus Google Scholar
 22. M Bacco, P Barsocchi, E Ferro, A Gotta, M. Ruggeri The Digitisation of Agriculture: a Survey of Research Activities on Smart Farming Array, 3–4 (2019), Article 100009, 10.1016/j.array.2019.100009 View PDFView articleView in ScopusGoogle Scholar[17]
 23. X Huang, C Zanni-Merk, B. Crémilleux Enhancing deep learning with semantics: An application to manufacturing time series analysis *Procedia Comput Sci*, 159 (2019),

- pp. 437-446, 10.1016/j.procs.2019.09.198
View PDFView articleView in
ScopusGoogle Scholar[18]
24. L Jiyu, Y Lan, W Jianwei, C Shengde, H Cong, L Qi, et al. Distribution law of rice pollen in the wind field of small UAV *Int J Agric Biol Eng*, 10 (2017), pp. 32-40, 10.25165/IJABE.V10I4.3103 Google Scholar
 25. Vishnu J Gaikwad, & Shriram Tandale. (2023). Prevalence and determinants of tobacco consumption among construction workers in Latur city of Maharashtra. *International Journal of Advances in Health Sciences (IJHS)*, 10(4), 1–5. Retrieved from <https://www.ijhsonline.com/index.php/IJHS/article/view/238>
 26. Abderahman Rejeb, Alireza Abdollahi, Karim Rejeb, Horst Treiblmaier, 2022. Drones in agriculture: A review and bibliometric analysis, *Computers and Electronics in Agriculture*, Volume 198, 107017,ISSN 0168-1699, <https://doi.org/10.1016/j.compag.2022.107017>. (<https://www.sciencedirect.com/science/article/pii/S0168169922003349>)
 27. C. Koç Design and Development of a Low-cost UAV for Pesticide Applications *J Agric Faculty Gaziosmanpasa Univ*, 34 (2017), pp. 94-103 <https://doi.org/10.13002/jafag4274>
 28. Yao, W. X., Lan, Y. B., Wen, S., Zhang, H., Zhang, Y., Wang, J., et al. (2019). Evaluation of droplet deposition and effect of variable-rate application by a manned helicopter with AG-NAV guía system. *Int. J. Agr. Biol. Eng.* 12, 172–178. doi: 10.25165/j.ijabe.20191201.4039
CrossRef Full Text | Google Scholar
 29. Som-ard, J.; Atzberger, C.; Izquierdo-Verdiguier, E.; Vuolo, F.; Immitzer, M. Remote Sensing Applications in Sugarcane Cultivation: A Review. *Remote. Sens.* 2021, 13, 4040.
 30. Sofonia, J.; Shendryk, Y.; Phinn, S.; Roelfsema, C.; Kendoul, F.; Skocaj, D. Monitoring Sugarcane Growth Response to Varying Nitrogen Application Rates: A Comparison of UAV SLAM LiDAR and Photogrammetry. *Int. J. Appl. Earth Obs. Geoinf.* 2019, 82, 101878.
 31. Duan, T.; Zheng, B.; Guo, W.; Ninomiya, S.; Guo, Y.; Chapman, S.C. Comparison of Ground Cover Estimates from Experiment Plots in Cotton, Sorghum and Sugarcane Based on Images and Ortho-Mosaics Captured by UAV. *Funct. Plant Biol.* 2017, 44, 169–183.
 32. Sanches, G.M.; Duft, D.G.; Kölln, O.T.; dos Luciano, A.C.S.; de Castro, S.G.Q.; Okuno, F.M.; Franco, H.C.J. The Potential for RGB Images Obtained Using Unmanned Aerial Vehicle to Assess and Predict Yield in Sugarcane Fields. *Int. J. Remote Sens.* 2018, 39, 5402–5414.
 33. Luna, I.; Lobo, A. Mapping Crop Planting Quality in Sugarcane from UAV Imagery: A Pilot Study in Nicaragua. *Remote Sens.* 2016, 8, 500. [Google Scholar] [CrossRef][Green Version]
 34. De Souza, C.H.W.; Lamparelli, R.A.C.; Rocha, J.V.; Magalhães, P.S.G. Mapping Skips in Sugarcane Fields Using Object-Based Analysis of Unmanned Aerial Vehicle (UAV) Images. *Comput. Electron. Agric.* 2017, 143, 49–56. [Google Scholar] [CrossRef]
 35. Miphokasap, P.; Wannasiri, W. Estimations of Nitrogen Concentration in Sugarcane Using Hyperspectral Imagery. *Sustainability* 2018, 10, 1266.