The Andhra Agric. J 71 (1): 109-116, 2024
doi :10.61657/aaj.2024.100

Drone application in oil palm based cropping system - experiences, challenges and prospects

M V Prasad, K L Mary Rani, A R N S Subbanna, S Shivashankar, B Lakshminarayana, K Srikanth, R Sai Kiran and K Mounika
ICAR-Indian Institute of Oil Palm Research, Pedavegi, Eluru, Andhra Pradesh – 534 435.

ABSTRACT

Indian agriculture is transforming from traditional to precision agriculture, one of the key technologies among them is drone technology. About 122 demonstrations covering 250 ha of oil palm based cropping system was conducted, study contains structured interview from 36 farmers from Andhra Pradesh. Data revealed, majority respondents (88%) have medium awareness on kisan drones in agriculture and in oil palm (83%). During demonstration, majority farmers used drones for insecticide spray (53%) followed by fungicide (25%) and nutrient (22%). All of them opined drone application saved time, labor, chemical/nutrient (15%) by reduces the amount of chemicals needed and the risk of over-application; reduced drudgery; enabled uniform spraying and timely spraying; suitable for all categories of farmers; useful for undulated terrains. For enhancing adoption of drone technology farmers (100%) perceived that there should be wider publicity, more demonstrations, custom hiring centers, drone transport vehicles, enhancing battery capacity are required; 85% opined for participatory mode demonstrations and with drone customized software. Hundred percent respondents opined to have drone facility in villages, either individually (88%) or group (12%) and wanted to purchase with the assistance from government. Farmers (>72%) revealed that the spraying cost using drone is more (28%) than conventional spraying. In spite of higher high spraying cost, the farmers inclined for drone spraying due to inherent advantages. Barriers in drone technology are lack of awareness and standard operating protocols, high capital cost for drone, limited technical training, support, service & security and these can be overcome by giving wider publicity, government support and developing crop specific Standard Operating Protocols, for drone spraying, needs immediate attention.

Key words: *Drone, Drudgery, Oil Palm, Farmer perception, Spraying and Strategies.*

India is dependent on imports to meet its edible oil requirements and is the largest importer of edible oils in the world. During 2020-21, India imported around 133.52 lakh tonnes of edible oils costing around ₹ 80,000 crore. Out of all the imported edible oils, the share of palm oil is about 56%, followed by soybean oil at 27%, and sunflower at 16%. Domestic edible oil production has not been able to keep pace with the growth in consumption which is above 25 million tonnes. The per capita consumption which was 15.8 kg per person per annum in 2012-13 has increased to around 19.00 kg at present. During 2020-21, the domestic production of edible oils was 122.89 lakh tonnes. Hence this necessitated import of edible oils. National Mission on Edible Oils - Oil Palm was started during 2021 in India, aim to enhance the edible oilseeds production and oils availability in the country by harnessing Oil Palm area expansion, increasing CPO production and to reduce import burden on edible oils.

Precision agriculture technology can benefit from more precise and efficient information provided by the advancement of information and communication technology (ICT), particularly the Internet of Things (IoT), which includes drone technology can gather and process data from multiple sources, assist in gathering weather data, soil profiles, and drainage data, and manage all crops more effectively (Lamb and Brown, 2001 and Mulla, 2013). Due to its success in photography, aerial mapping, and surveillance, drone technology is being used in plantations to monitor broad areas (Al-Najjar et al., 2019).

Indian agriculture is transforming from traditional to precision agriculture for enhancing the economic productivity, input use efficiency and environmental sustainability. Novel technologies like internet of things (Gill et al., 2017), artificial intelligence (Shadrin et al., 2019) remote sensing has high potential for precision agriculture (Feng *et al.*, 2019; Khanna and Kaur, 2019) and smart farming (Tang *et al.*, 2021). Satellites, manned aircrafts and drones are popular remote-sensing technologies used to monitor crops through images. Drones, popularly known as Unmanned Aerial Vehicles (UAVs), are of great importance as they have multiple advantages in comparison with other remote-sensing technologies (Rejeb et al., 2022) Manifold application areas of drones in agriculture include crop management like mapping, monitoring, precision irrigation, precision weed, pest and disease management; crop and growth monitoring, yield estimation, water stress assessment (Kalantar et al., 2022).

Developed countries have already begun using UAVs for precision agriculture, photogrammetry, and remote sensing. It is highly rapid and could lessen a farmer's workload. UAVs are typically fitted with cameras and sensors for crop monitoring (Natu and Kulkarni, 2016) Precision agriculture has advanced too far in the modern period to boost crop output. More than 70% of the rural population, particularly in developing nations like India, is dependent on agriculture. Diseases cause severe losses in agricultural and horticultural crops. These diseases, which lower crop output, are caused by pathogens and insects. In order to improve crop quality, pests and disease are eliminated using insecticides and fungicides (Mogili and Deepak, 2018). Manually spraying pesticides on crops can result in up to one million cases of illness, unmanned aerial vehicles (UAVs) are aircraft that spray pesticides to prevent human health issues that could arise from hand spraying, where manpower and equipment are difficult to employ, UAVs are simple to use (Food and Agriculture Organization, 2018). A Project on Agricultural Drone Demonstration was implemented at ICAR - Indian Institute of Oil Palm Research and a study has been conducted. Hence, the present study was conducted to know the perception of farmers on application of drones, experiences, challenges faced and prospects.

MATERIAL AND METHODS

Agricultural Drones Project was sanctioned by ICAR, New Delhi, to Indian Institute of Oil Palm Research, Pedavegi, to demonstrate Drone Technology in agriculture. Demonstrations (122) were conducted in an area of 250 ha in oil palm based cropping systems having intercrops viz., chilli, maize, okra, banana, watermelon, tobacco, pulses, vegetables and other mono crops viz., paddy, maize, sugarcane, coconut, banana, watermelon, vegetables.

The study was conducted in Eluru district of Andhra Pradesh during 2023. To study the objective, interview schedule was developed to collect the data from sample respondents. Interview schedule was constructed and pilot tested in non-sample area and finalized. The structured interview schedule was administered to a randomly selected sample of 36 farmers (sample selected with simple random sampling method) owning oil palm based cropping system. Schedule consists of a dichotomous question or open-ended questions. Ranking was based on 5-point continuum to the factors contributing for wide spread use of drones and specifically for wide spread use of drones in agriculture and specifically in oil palm based cropping system. Data collected was subjected to analysis, suitable statistical tools were used. Frequency percentages were calculated to measure the parameters selected. Tables/illustrations were prepared and presented for all parameters. Results were suitable presented, discussed and inferences drawn.

RESULTS AND DISCUSSION

Awareness on kisan drone application in agriculture

Results of the study (Table 1) on awareness on kisan drones' application in agriculture reveals that 86% of the respondents had medium awareness followed by low (11%) and no idea (3%). Recent times farmers are coming across use of drones through mass media for different purposes *i.e.*, videography, television network channels, survey of lands and spraying etc., Hence farmers might have come across such occasions and could aware about their use in agriculture also.

Frequency of Drones usage in Agriculture

Results from Table 2, indicated that 58% farmers not used or come across using the drones in agriculture, where in 42% of the farmers used occasionally for spraying and survey operations in their fields. Farmers revealed that drones were used

Table 1. Awareness on Kisan Drones application in agriculture

Awareness	Frequency	Percentage
Medium	31	86
Low	4	11
No idea	1	3
Total	36	100

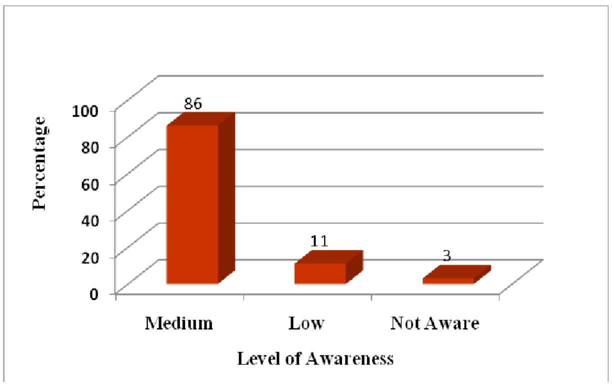

Fig. 1 Awareness on Kisan Drones application in agriculture

for land survey and spraying operations, organised or hosted by public/NGOs and private organisations under CSR activity during last couple of years. They could see the demonstration activity organised in their village or in their fields.

Table 2. Frequency of Drones usage in agricul ture

Drones Usage	Frequency	Percentage
Occasionally	15	42
Not used	21	58
Total	**36**	**100**

Drones usage in different crops

It could be inferred from results (Table 3), that 55% of the famers used drone in oil palm followed by banana, chilli (11%), tobacco (5%) and vegetables, paddy, green gram, okra and brinjal. Since the drone demonstrations were concentrated mostly in villages having oil palm based cropping system, oil palm crop was covered predominantly. Adjoining farmers having other crops also used drone, to see the suitability and adoptability. This demonstration could lead them to have way forward to use drones for spraying nutrients, insecticides and fungicides in field and plantation crops in different seasons.

Table 3. Drones usage in different crops

Crop	Frequency	Percentage
Oil Palm	20	55
Watermelon	1	3
Banana	4	11
Vegetables	1	3
Paddy	1	3
Green gram	1	3
Chilli	4	11
Okra	1	3
Brinjal	1	3
Tobacco	2	5
Total	**36**	**100**

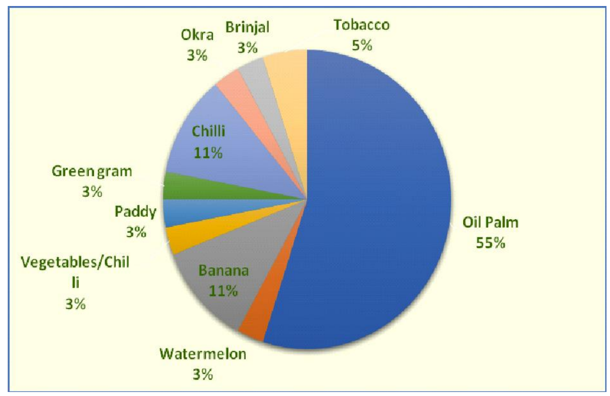

Fig. 2. Drones usage in different crops

Agrochemicals sprayed by using Drone

During drone demonstration farmers were given a choice of spraying chemicals, 33% of the farmers used drone for spraying of pesticides followed by fungicide (28%), nutrients (22%) and biocontrol agents (17%). Farmers are inclined to take up prophylactic measures for plant protection followed by plant health management. Hence, they adopted the drone accordingly.

Table 4. Different agrochemicals sprayed by using Drone

Input	Frequency	Percentage
Pesticides	12	33
Fungicides	10	28
Biocontrol agents	6	17
Nutrients	8	22
Total	**36**	**100**

Cost incurred for spray application per acre

Results from the Table 5, indicated that Rs. 1000-2000 per acre was incurred for drone spraying by 69% farmers and 50% farmers for manual spraying application. About 36% manual spraying farmers and 6% drone spraying farmers incurred spraying cost up to Rs.1000 per acre. About 6 % of drone spraying farmers and 3% manual application farmers are incurring spraying cost of Rs. 3000 and more per acre. This could be due to higher drone hiring charges irrespective of chemical / labour cost.

Table 5. Cost of spraying per acre in different methods

Method	Manual spray application		Drone spray application	
Cost of spraying	Frequency	Percentage	Frequency	Percentage
0 - 1000	13	36	2	6
1000-2000	18	50	25	69
2000-3000	4	11	7	19
> 3000	1	3	2	6
Total	**36**	**100**	**36**	**100**

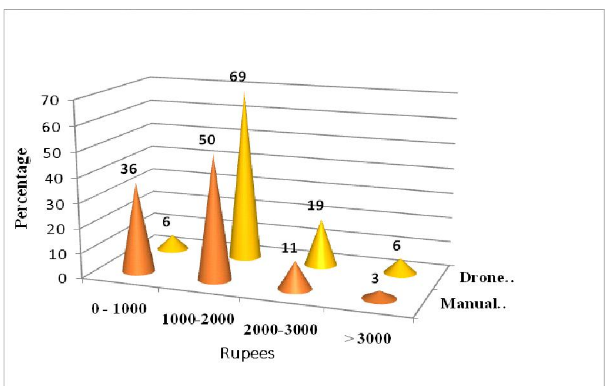

Fig. 3. Cost of spraying per acre in different methods

Time required for manual spray application per acre

Study results from the Table 6, revealed that 75% farmers could complete manual spray in an acre in 30-60 minutes, followed by >120 minutes by 17% farmers, 60-90 minutes by 5% farmers and 90-120 minutes by 3 % farmers. Manual spray application involves filling the sprayer with chemical from a static point in the field and spraying, or carrying the spray fluid to the point of operation by one more person and filling the sprayer. Operating person will take rest during spraying operations. This took more time for manual spraying.

Table 6. Time required for manual spray application per acre

Minutes	Frequency	Percentage
30 – 60	27	75
60 - 90	2	5
90 - 120	1	3
>120	6	17
Total	**36**	**100**

Time required for Drone spray application per acre

Results from Table 7, revealed that 55% farmers could complete drone spray in an acre in 30-45 minutes in oil palm based cropping system, followed by 15-30 minutes by 42% farmers, 3 % farmers responded that they finished spraying operation in < 15 minutes. Drone comprising of electronic, mechanical and digital technologies basically operates at a faster rate compared to manual process. Drone spray application involves application of spray fluid, for which, every time the fluid is over, drone returns to the starting point and after refilling with the fluid resumes spraying in few minutes - from the same point, where it left. This entire process of filling and starting the spraying operation from same point involves very less time compared to manual spray application. Hence drone operation covers large area with uniform spraying in unit time compared to manual spray application.

Table 7. Time required for Drone application in spraying per acre

Minutes	Frequency	Percentage
< 15 minutes	1	3
15 - 30 minutes	15	42
30 - 45 minutes	20	55
Total	**36**	**100**

Perception of farmers about Drone technology

Hundred percent of farmers perceived that drone technology will save time, input, labour; easy operation; reduced drudgery and uniform spraying (Table 8). Suitable for all field crops, all terrains, reduce pest and disease infestation (Filho et al., 2020) This they might have seen physically from the drone spraying operation, hence perceived positive attributes of drone technology (Frempong and Akaba, 2019).

Table 8. Perception of farmers about Drone technology

Parameter	Frequency	Percentage
Save time saving, input, labour, easy, reduced drudgery, uniform spraying, suitable for all field crops, all terrains, and reduced pest and disease infestation.	36	100

Perception of farmers about spraying cost by using Drone technology

Results from the above table revealed that, majority of the respondents (75%) perceived that drone spray saved cost of spraying (Table 9). This perception of farmers, could be due to cost of chemical + labor hiring cost + sprayer hiring cost in different seasons, might have been higher in manual spraying method.

Table 9. Perception of farmers about spraying cost by using Drone technology

Parameter	Frequency	Percentage
Saving in spraying cost	27	75
No saving in spraying cost	9	25
Total	**36**	**100**

Barriers for low spread of Drone technology

Study results from the Table 10, revealed that all the respondents (100) perceived the following are the barriers for slow spread of drone technology viz., quick discharging of batteries, no wired electricity/ charging Points in farms for charging batteries, long battery charging time, inadequate trained / technical manpower, high capital investment, drifting of chemicals during spraying, Obstacles in fields(electric lines , trees, bunds), frequent repairs to the drone, not suitable for powder formulations, difficult to spray in tall oil palm plantations, difficulty in transporting drones, inadequate SOP's for crop-wise spraying, drifting of drones due to wind, lower surface of leaves not covered, high repairs and maintenance cost, limited landing space for drones in fields, requires high skills to operate,. About 94% perceived drone operational thrust exists on plants and flowers, which are the barriers for slow spread of drone technology.

Perceived suggestions for enhancing adoption of Drone technology

Results from Table 11, revealed that all the respondents (100) perceived the following suggestions would enhance the adoption of drone technology *viz.*, wider publicity and awareness among farmers, conducting more demonstrations in the farmer fields, development of SOP's for more crops and inputs, increasing subsidy for drone, setting up of drone based custom hiring centers, providing drone transport vehicles, providing financial assistance for drone purchases, increasing the battery capacity / longevity, reducing the battery charging time, training for rural youth and progressive farmers, developing cost effective (Low cost) drones, providing drones at village level through RBK's and line departments, developing district level master trainers, development of drone service centers in small towns, providing battery charging points in fields, up scaling through FPO's / NGO/ SHG etc., entrepreneurship development and cost effective(low cost) batteries. Majority perceived those conducting demonstrations in participatory mode (94%) and not required customized drone software (75%).

Table 10. Barriers for low spread of Drone technology

Reason	Frequency	Percentage
Quick discharging of batteries	36	100
No wired electricity/ charging Points in farms for charging batteries	36	100
Long battery charging time	36	100
Inadequate trained / technical manpower	36	100
High capital investment	36	100
Drifting of chemicals during spraying	36	100
Obstacles in fields (electric lines, trees, bunds)	36	100
Frequent repairs to the drone	36	100
Not suitable for powder formulations	36	100
Difficult to spray in tall oil palm plantations	36	100
Difficulty in transporting Drones	36	100
Inadequate SOPs for crop-wise spraying	36	100
Drifting of drones due to wind	36	100
Lower surface of leaves not covered	36	100
High repairs and maintenance cost	36	100
Limited landing space for drones in fields	36	100
Requires high skills to operate	36	100
Drone operational thrust exists on plants and flowers	34	94

Table 11. Perceived suggestions for enhancing adoption of drone technology

Parameter	Frequency	Percentage
Wider publicity and awareness among farmers	36	100
Conducting more demonstrations in the farmers' fields	36	100
Development of SOPs for more crops and inputs	36	100
Increasing subsidy for drone	36	100
Setting up of drone based custom hiring centers	36	100
Providing drone transport vehicles	36	100
Providing financial assistance for drone purchases	36	100
Increasing the battery capacity / Longevity	36	100
Reducing the battery charging time	36	100
Training for rural youth and Progressive farmers	36	100
Developing cost effective (Low cost) drones	36	100
Providing drones at village level through RBK's and line departments	36	100
Developing district level master Trainers	36	100
Development of drone service centers in small towns	36	100
Providing battery charging points in fields	36	100
Up scaling through FPO's / NGO/ SHG etc.	36	100
Entrepreneurship development	36	100
Cost effective (low cost) batteries	36	100
Conducting demonstrations in participatory mode	34	94
Not required customized drone software	27	75

Critical factors influencing farmers decision, to increase the use of Drones in future

All farmers (100%) perceived that saving of labor and resources, spraying of chemical evenly, reduce drudgery and timely spraying are the critical factors influencing the farmers decision to increase the drone adoption (Table 12).

Perceived key factors for limited use of Drones in Agriculture

Results of the study from Table 13 indicated that all farmers (100%) perceived that lack of awareness about drones, high capital cost of drone, limited technical support and maintenance services and lack of technical knowledge &training, had scored high, are the key factors for wide spread use of drones in agriculture.

Table 12. Critical factors involved in choosing drone spraying over others

Factors	Rank - High	Frequency	Percentage
Saving of labor and resources	5	36	100
Spraying of chemical evenly	5	36	100
Reducing drudgery	5	36	100
Timely spraying	5	36	100

Table 13. Key factors for limited use of drones in agriculture

Factors	Rank – High	Frequency	Percentage
Lack of awareness about drones	5	36	100
High capital cost of drone	5	36	100
Limited technical support and maintenance services	5	36	100
Lack of technical knowledge and training	5	36	100

Placement of Drone for use at a common place

Results from Table 14 revealed that all farmers (100%) perceived to have drone to be placed at village level for common purpose. They might have perceived that availability of drone at village would be accessible and handy, whenever required.

Table 14. Placement of drone for use

Place	Frequency	Percentage
Village	36	100

Recommend the use of drones by farmers to other farmers

Study results from Table 15 revealed that, 97% farmers perceived they strongly recommend the drone technology to other farmers and 3% of them perceived to recommend the drone technology to other farmers with precautions.

Perception of owning a Drone

Results from Table 16 revealed that 86% farmers perceived that they want to own the drone with government subsidy, 5.5% perceived to have drone in a group or not required. Three percent farmers perceived to have individually. Since cost of drone is high, hence farmers perceived to have drone with government subsidy.

Table 15. Farmers recommendation of Dronesusage to other farmers

Parameter	Frequency	Percentage
Yes, strongly recommend	35	97
Yes, strongly recommend with precautions	1	3
Total	**36**	**100**

Table 16. Farmers Perception on owning a Drone

Owning a drone	Frequency	Percentage
Yes, individually	1	3
Yes, as part of a group	2	5.5
Yes with Govt. subsidy	31	86
NOT Required	2	5.5
Total	**36**	**100**

CONCLUSION

It can be concluded that though the application cost is a little higher in drone spraying compared to manual spraying. Farmers are inclined to go for drone spraying due to inherent advantages viz., saving of chemical/nutrients (15%) or reduces the amount of chemicals needed and the risk of over-application, time, less labor dependency, uniform spraying, less drudgery, ease of spraying, less operational hazards. Strategies may be evolved to overcome existing barriers in drone technology for its wider adoption. With wider publicity, drones may be made available for spray applications to needy individuals or groups of farmers at village level with government support. In situations where farmers, rely heavily on pesticide and nutrient spraying for management of pests, diseases and nutrient deficiencies; drones can be definitely deployed not only to enhance spray efficiency but also to reduce time and operational hazards. Lack of crop specific Standard Operating Protocols (SOPs) for drone spraying calls for immediate attention to bring crop specific SOPs. Financial, technical and infrastructure support is required to be given from government to start ups for required domestic drone technology and service, to meet the inevitable future demands for UAV for survey, mapping, spraying, surveillance etc.

Acknowledgements

Authors thank Indian Council of Agriculture Research, New Delhi for sanctioning the project, M/s. Vyomik who rendered drone services, scientists, staff and farmers who have associated in the project implementation and survey.

LITERATURE CITED

Al-Najjar H A H, Kalantar B, Pradhan B, and Saeidi V 2019. Land cover classification from fused DSM and UAV images using convolutional neural networks. *Remote Sensing,* H(12):1461

Feng X, Yan F and Liu X 2019. Study of wireless communication technologies on Internet of Things for precision agriculture. *Wireless Pers. Commun.,* 108 (3), 1785

Filho F H I, Heldens W B, Kong Z and Lange E S 2020. Drones: Innovative Technology for Use in Precision Pest Management. J. Econ. Entomol., 113, 1–25. 1802.

Food and Agriculture Organisation 2018. E-agriculture in action: drones for agriculture, united nations. Available at: http://www.fao.org/3/I8494EN/i8494en.pdf.

Frempong F A and Akaba S 2019. Socio-Economic Impact and Acceptance Study of Drone-Applied Pesticide on Maize in Ghana, Technical Centre for Agricultural and Rural Cooperation (CTA), pp 29

Gill S S, Chana I and Buyya R 2017. IoT based agriculture as a cloud and big data service: the beginning of digital India. *J. Org. and End User Comput.* (JOEUC), 29 (4), 1–23.

Kalantar B, Khuzaimah Z, Nawi N M, Adam S N, Emeka O J and Ueda N 2022. Application and Potential of Drone Technology in Oil Palm Plantation: Potential and Limitations. *Journal of Sensors,* https://doi.org/10.1155/2022/5385505

Khanna A and Kaur S 2019. Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture. *Comput. Electron. Agric.,* 157, 218–231.

Lamb D W and Brown R B 2001. Precision agriculture: remote-sensing and mapping of weeds in crops. *Journal of Agricultural Engineering Research,* 78(2):117-125

Mogili U R and Deepak B B 2018. Review on application of drone systems in precision agriculture. *Procedia Comput. Scie.*, 133, 502–509. https://doi.org/10.1016/j.procs.2018.07.063.

Mulla D J 2013. Twenty five years of remote sensing in precision agriculture: key advances and remaining knowledge gaps. Biosystems Engineering, 114(4):358-371

Natu and Kulkarni S C 2016. Adoption and Utilization of Drones for Advanced Precision Farming: A Review. published in International Journal on Recent and Innovation Trends in Computing and Communication, 4(5) : 563 - 565

Operational Guidelines of National Mission on Edible Oils-Oil Palm (NMEO-OP) 2021. Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare Government of India, P. 2, https://nfsm.gov.in/Guidelines/NMEO-OPGUIEDELINES.pdf

Rejeb A, Abdollahi A, Rejeb K and Treiblmaier H 2022. Drones in agriculture: A review and bibliometric analysis. *Computers and Electronics in Agriculture*, 198: 107017

Shadrin D, Menshchikov A, Somov A, Bornemann G, Hauslage J and Fedorov M 2019. Enabling precision agriculture through embedded sensing with artificial intelligence. *IEEE Trans. Instrum. Meas.*, 69 (7), 4103–4113.

Tang Y, Dananjayan S, Hou C, Guo Q, Luo S and He Y 2021. A survey on the 5G network and its impact on agriculture: challenges and opportunities. *Comput. Electron. Agric.*, 180, 105895 https://doi.org/10.1016/j.compag.2020.105895.

Received on 20.01.2024 and Accepted on 25.02.2024