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WSN and IoT Based Monitoring of Various Macronutrient Parameters and Disease Control of Banana Crop

Lina Desai, R.P. Singh, D.G. Khairnar

***Abstract:** In India, banana is an important fruit. In this research, we designed and develop a precision agriculture system to monitor the various macronutrients and various crucial parameters to control and early detection of various diseases of banana crop using Wireless Sensor Networks (WSN) and Internet of Things (IoT). Developed precision agriculture system is used various sensors to sense and measure various micronutrients like Magnesium (Mg), Calcium (Ca), Sulfur (S), nitrite content in soil, ground water quality, crop growth, pest detection, crop on line monitoring, animal intrusion into the field and so on. It also measures the different parameters like change in weather, temperature, humidity, moisture changes in soil, quality and fertility of soil, various weeds, and level of water. Precision agriculture system implemented using advance sensors and improved technologies like WSN, IoT. Research experimental results show significant improvement in quality of banana fruit and overall production of banana crop. Before design and implementation we have carried out a detailed literature review on various approaches of precision monitoring system using Internet of Things (IoT). Proposed precision agriculture system can be used to automate and complete control of all farming processes. Our major focused is on monitoring macronutrients like Magnesium (Mg), Calcium (Ca) and Sulfur (S) parameters, to supply balance macronutrients using automatic action and early detection of diseases and control of Banana Crops System which will result to increase the productivity and quality of Banana products.*

This precision agriculture system keep farmers/users updated and empowers with minimum manual tasks.

***Keywords:** Internet of Things, Wireless Sensor Networks, Monitoring, Macronutrients, Parameters, Magnesium (Mg), Calcium (Ca), Sulfur (S), Disease Control, Content in soil , Cloud Database Server, Precision Agriculture, Monitoring System, Banana Crops,, Productivity.*

I. INTRODUCTION

Agriculture is core sector to provide food and raw material for human beings and other industries. It plays major role in growth of countries depends on agriculture as its main employment source. Recent development and adoption of latest technologies in agriculture, helps these countries to increase the yield and making them independent in terms of food and raw materials [1, 2, 3 and 4].

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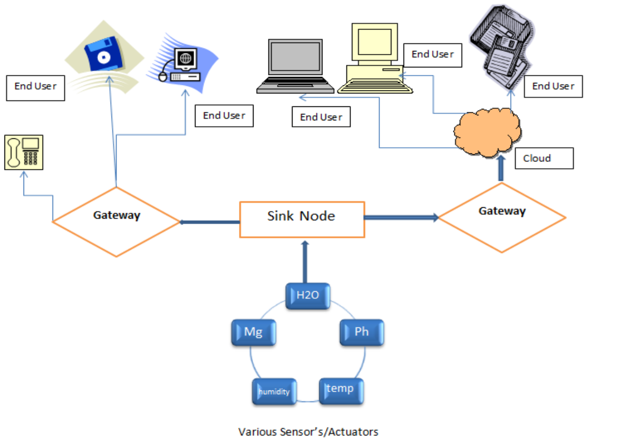
This indeed helped them to improve their economy and livelihood of people. Wireless sensor networks, Internet of Things and precision agriculture is at the center of these advance technologies [5, 6, 7 and 8]. In this research, we build and develop of precision agriculture system for monitoring different parameters and early detection of diseases and control of Banana Crops System. Figure-1 shows block diagram of Precision Macronutrients Monitoring System of Banana Crop using Wireless Sensor Network (WSN) and Internet of Things (IoT). The monitoring system for banana crop using wireless sensors will be use for sensing and measuring various crucial parameters. Afterwards these sense parameters will be use for Disease Control and automation of Precision Monitoring System of Banana Crop using WSN and IoT [9, 10, 11, and 12].



Figure–1: Block Diagram of Precision Macronutrients Monitoring System of Banana Crop Using WSN and IoT.

As IoT is an Internet of three: People to Machine (things), People to People, and Machine to Machine**.** Now a days due to advanced sensor technology, improved wireless sensor networking and Internet of Things, the precision agriculture technologies are taking front row seats in agriculture research [13, 14 and 15]. The research in this field include the monitoring and supply of required parameters with precision to the crop which can prevent the diseases and increase the productivity with minimal and précised input. Precision Agriculture provides the one kind of decision support system for farm management [16 and 17].

II. PROBLEM FORMULATION AND IMPORTANCE OF MACRONUTRIENTS LIKE MAGNISIUM (MG), CALCIUM (CA) AND SULFUR (S) FOR BANANA CROPS GROWTH

There are many conventional or traditional methods for measuring and evaluating status of soil properties like macronutrients and various soils contains.

To decide requirements of fertilizer for the specific crop e.g. Effects soil parameters and contents of nutrient. Experiments using field pot, testing of soil and analysis of plants. In these traditional methods, soil samples are sent to a testing laboratory where the researches operate the equipments, it is time consuming, labor intensive and costly. There are few more demerits like high threshold, more cost, more steps and costly equipments required. It is impossible to measure the soil macronutrients like Magnesium (Mg), Calcium (Ca), Sulfur (S) and other contents quickly. In our proposed method we can overcome all these demerits [18 , 19 and 20]. In this research work, we developed Precision Monitoring System for Banana Crop Using IoT and WSN. A soil which is neither too acidic nor too alkaline, rich in organic material with balance macronutrients content is good for banana crops. Our aim is to increased productivity of banana fruits (Production Yield). We can measure and take necessary actions to balance requirements using our proposed Precision Monitoring System for Banana Crop so that there is complete growth of plants with good productivity. In this research work, we formulate the problem and discussed the importance of various macronutrients parameters like Magnesium, Calcium and Sulfur for banana crop. A major constrain to optimum growth of banana crop and productivity is due to unbalance soil properties and fertility. Soil fertility and properties can be measured and corrected using our proposed Precision Agriculture system using WSN and IoT. But farmers must be aware and they need precision parameter monitoring system to arrive at the correct decisions regarding required nutrition's, macronutrients and supply of fertilizers to balance soil properties and other parameters. Banana crop grows well in a certain air and soil temperature range, it needs correct relative humidity. Irrigation of water whenever required is also very much important for banana crop [21, 22 and 23]. For banana cultivation, deep, rich loamy soil with correct pH value is at most important. Soil for banana crop should have good drainage, adequate fertility and soil moisture is essential for the optimum growth of banana plants. Balance contents of Macronutrients like Magnesium (Mg), Calcium (Ca) and Sulfur (S) is very essential for the complete growth of banana crop. Magnesium is a secondary macronutrient absorbed as Mg^{2+}. It is very crucial constituent of the chlorophyll molecule.

Figure – 2 (a) Symptoms of Magnesium Deficiency

Figure – 2 (b) Effects of Calcium Deficiency

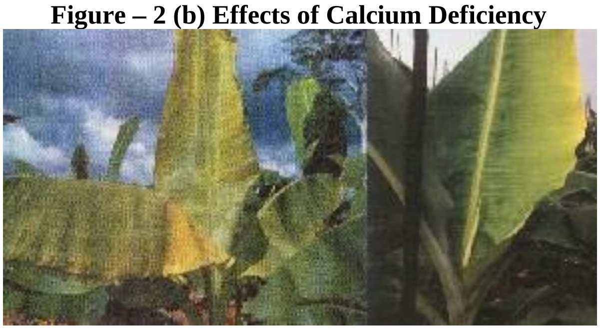


Figure – 2 (C) Lacunas of Sulfur, yellowing the complete lamina

Soils with deficiency in macronutrients are not suitable for banana crop cultivation [20, 21, 22 and 23]. If soil contains less Magnesium, Calcium and Sulfur Macronutrients it makes impacts on banana crops. Due to Magnesium deficiency it develops yellowish chlorosis at the center and midrib, margins are green. There are other symptoms like purple mottling; petioles and leaf sheaths are separated from pseudo stem. Figure 2 (a) shows the Symptoms of Magnesium Deficiency. In banana crops calcium deficiency is a major problem and it significantly reduces fruit quality. It creates the major moisture stress and further it causes interrupts to uptake the macronutrients of calcium and results into deficiencies in fruits. Effects of Calcium Deficiency are presented in Figure 2 (b). Sulfur (S) is very essential macronutrient for protein formation in banana crops.

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It helps for the production of healthy and productive plants and it is very much essential precondition for superior quality and high yields of banana fruits [29, 30, 31 and 32]. Because of deficiency of sulfur it is yellowing the complete lamina. It also reduces the size and chlorotic the leaves of banana crops. Figure 2 (c) represents the example due to Lacunas of Sulfur.

III. HARDWARE AND SOFTWARE ARCHITECTURE BLOCK DIAGRAM OF PRECISION AGRICULTURE SYSTEM OF BANANA CROPS.

The Cloud servers will acquire the data and it can be used the way user wants to see it on web, smart phones, smart devices, monitoring devices, PCs etc. these data is further used for monitoring, controlling and actuation purpose. Figure – 3 - (a) and 3 - (b) shows the block diagram of Hardware and Software architecture of Precision Agriculture System using Wireless Sensor Networks and Internet of Things. One can develop the automated decision support system for the Banana Crops in order to avoid many deficiency and significant increase in productivity of Banana Crops. This can help to provide précised required input to each tree, further reducing the cost of pesticides and increase in yields.

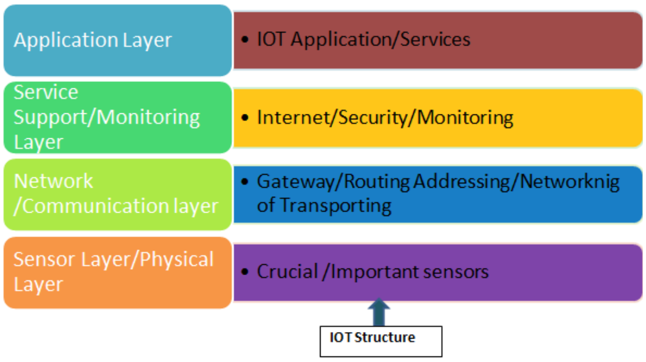

Figure – 3 - (a)

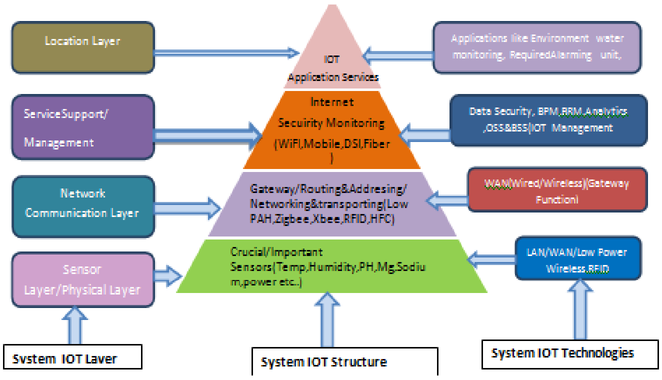

Figure 3 - (b)

Figure 3 - (a & b) Block Diagram of Hardware and Software Architecture of Precision Agriculture System Using WSN and IoT

Proposed Precision Agriculture System consists of four layers: physical or sensor layer, network management or communication layer, service support or monitoring layer and IoT application or services layer. Each and every layer is very important and has certain roles and responsibilities in Precision Agriculture System. Sensor or physical layer is used for crucial information collection and it consists of various sensors, actuators etc. Crucial sensors are helps to sense and measure the various parameters like temperature of air and soil, relative humidity, water potential of banana field, pH value of soil, Electric conductivity of soil, salinity of banana field soil, Moisture changes in soil, soil quality, and fertility of soil, water ground quality, and crop growth in the real field. Network management or communication layer acts as second important layer of banana crop precision system. This layer consists of various communication technologies such as Routers, Gateways, NFC, RFID, GSM, Wi-Fi, 3G, 4G, UMTS, Bluetooth, BLE, ZigBee, SLowPAN, Wireless Metropolitan Access Networks, Broadband Wireless Access (BWA) WiMax, etc. Various Gateways, Routing Addressing, Networking and Transportation protocols are used as enabling technologies for smooth functioning of this layer. Internet Connectivity, strong and proper security and monitoring are very crucial and necessary and it is supported and provided by third layer called as Service support or monitoring layer. Roles and responsibilities executed and maintained in this layer are data formation, classification and creation, proper monitoring and correct decision making etc. are happened in service support or monitoring layer. IoT Application and services is the fourth layer in system. In this layer all Precision Agriculture applications are monitored, operated and integrated so that it can be used for user friendly interface applications. In this layer various end users like farmers, smart phones, and personal controlling devices are used to monitor and control the precision agriculture fields. With the help of this user friendly layer, farmers can take prompt and correct decision to take necessary actions to protect their crops from various unbalance parameters and can also find out the soil or macro nutritional deficiencies like Magnesium (Mg), Calcium (Ca) as well as Sulfur (S) if any and supply the balanced fertilizers to make crops more and more healthy and produces better fruits or food production with excellent yield.

IV. EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATIONS

Our proposed system is used to sense and measure important parameters like Magnesium (Mg), Calcium (Ca) and Sulfur (S), air temperature, soil temperature, relative humidity, relative moisture of banana fields soil, pH value, water potential of banana field soil, Electric Conductivity of soil, salinity of banana field soil etc. As mentioned in our problem formulation and importance of various macronutrients, in this research experiments our main focused is on three macronutrients Magnesium (Mg), Calcium (Ca) and Sulfur (S) for banana crops. With the help of our precision agriculture system, we sense, measure, control, automate and balance the micronutrients required to banana plants. Initially proposed system is used to sense and measure all these important parameters and further it is utilized for monitoring, controlling and actuation purpose. Data Sensing and Measuring stage consists of many data sensing, monitoring and measuring sensor nodes.

Various sensors are deployed at many locations to sense, measure and monitor required parameters. Different crucial sensors are temperature, humidity, soil sensors to measure quality of soil, temperature of soil and air, moisture of soil, soil quality, Salinity of soil and fertility of soil etc. Selection of right sensor is done after study of detailed technical specifications and necessary features. Finally, our aim is to increase the productivity of banana fruits (Production Yield) with the help of proposed improved precision agriculture system

V. EXPERIMENTAL SET UP AND TECHNICAL SPECIFICATIONS

In our research and experimental arrangement, banana field was monitored and various sensor nodes were deployed in one hector banana field to sense and measure banana fields temperature, relative humidity, soil properties, Magnesium, Calcium and Sulfur contents. Every sensor node is monitoring various parameters in 5 minutes intervals over 10 hours duration from 9 am to 6 pm. Around 100 data requests was sent by the coordinator (Sink Node) and there were 25 responses from every sensor node. There was loss of 3 to 4 packets or sometimes there may be some error in received data. In terms of data information, there is a loss of 3 to 4% of actual data. The sensor nodes and coordinator (Sink Node) is around 20 to 25 meters and it was increased or decreased on the basis of reliable and robust connection establishment. We also found that, the reliable distance between sensor nodes and coordinators (Sink Nodes) is around 22 meters. Banana field real time arrangement measures and monitored the actual parameters. Measured real time data is transmitted to coordinator (sink node) and all measured data was scanned at 15 seconds time interval and through Gateways it is transmitted using wireless network protocol to the cloud at every 10 minutes interval. There are many sensors to measure the temperature and relative humidity values from 9 am to 6 pm at regular interval of time. It is not possible to present all the experimental results graphically and therefore we just mentioned the minimum temperature measured was 11.50^0 Celsius and maximum temperature recorded was 37.60^0 Celsius. Similarly, minimum and maximum relative humidity measured was 52% and 78% respectively. A banana plant grows well in 15 to 35^0 C temperature range and 75 to 85% of a relative humidity. Due to optimum growth of banana plant results into significant increase in banana Yield.

VI. MEASUREMENTS OF PH VALUE OF BANANA FIELD SOIL

In India, four months of monsoon June to September with an average rainfall is most important for vigorous vegetative growth of banana plant. Figure 4 shows example of pH value Measurement of Banana Field Soil from January 2019 to December 2019. Deep, rich loamy soil with pH value between 6.5 to 7.5 is most preferred for banana cultivation. Soil for banana should have good drainage, adequate fertility and moisture. Saline solid, Calcareous soils are not suitable for banana cultivation. A soil which is neither too acidic nor too alkaline, rich in organic material with high nitrogen content, adequate phosphorus level and plenty of potash is good for banana.

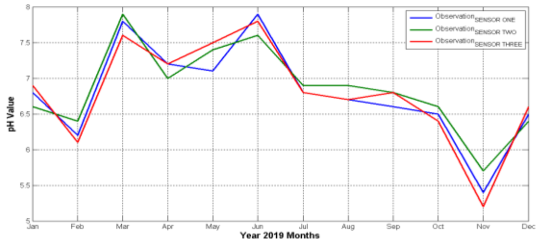

Figure – 4: Example of pH value Measurement of Banana Field Soil from January 2019 to December 2019.

VII. IMPROVEMENT IN BANANA YIELD DUE TO BALANCE SUPPLY OF MAGNESIUM (Mg) MACRONUTRIENTS

Optimum Yield Production Formula: We defined the optimum yield production formula for our precision agriculture system

Yield of Banana Plant (Y) = Temperature (T) × Soil Moisture (M) × Area of Banana Crop Field (A) X 100

T = Optimal Temperature Range (Banana Crops) 15 to 35^0 C.

M = Soil Moisture Suitable Temperature Range (Banana Crops) 75 to 85%

Since in real-time Banana plants needs correct soil parameters and balance macronutrients like Magnesium, Calcium and Sulfur to get the maximum growth and yield of banana fruits, in our experiments we measured all soil properties present in banana field using our proposed method and experimental results are compared with conventional method. As shown in graphical results we conducted different sets of experiments, and observations were noted using conventional method and our proposed method. We observed effect of balance Magnesium macronutrients to the overall growth and production of banana yields. As shown in Figure 5 – (a) and (b), there is significant improvement in banana fruits production in case of our proposed system using IoT and WSN method compared to conventional method. Our system helps early detection of Magnesium Deficiency Symptoms and due to balance quantity of Magnesium it removes the yellowish chlorosis at the center and midrib. Finally it improved the banana fruit quality and there is significant improvement in banana fruit production.

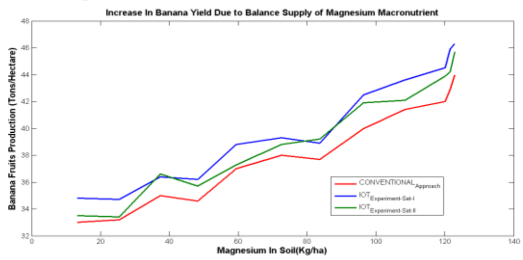

Figure – 5 – (a): Comparison of Effect of Balance Magnesium Macronutrients Supply to Banana Crop using IoT Based System and Conventional Approach.

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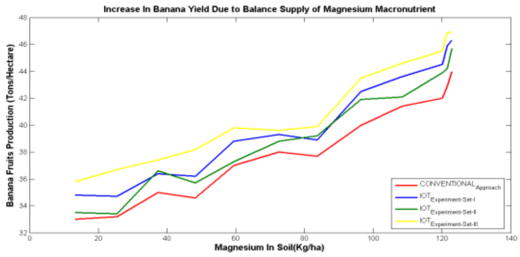

Figure – 5 – (b): Comparison of Effect of Balance Magnesium Macronutrients Supply to Banana Crop using IoT Based System and Conventional Approach.

VIII. IMPROVEMENT IN BANANA FRUITS HANDS PER BUNCH DUE TO BALANCE SUPPLY OF MAGNESIUM (Mg), CALCIUM (Ca) and SULFUR (S) MACRONUTRIENTS

As Magnesium, Calcium and Sulfur are the essential macronutrients for the full growth of banana plant, They help for the production of healthy and productive plants and it is very much essential precondition for superior quality and high yields of banana fruits. Balance supply of Magnesium, Calcium and Sulfur Macronutrients reduces moisture stress and further it helps to uptake the all micronutrients and removes the deficiencies effects in banana fruits. Sulfur (S) is very essential macronutrient for protein formation in banana crops. It helps for the production of healthy and productive plants and it is very much essential precondition for superior quality and high yields of banana fruits it controls the stomata, sugar transportation, and helps to reduce the susceptible banana plant diseases.

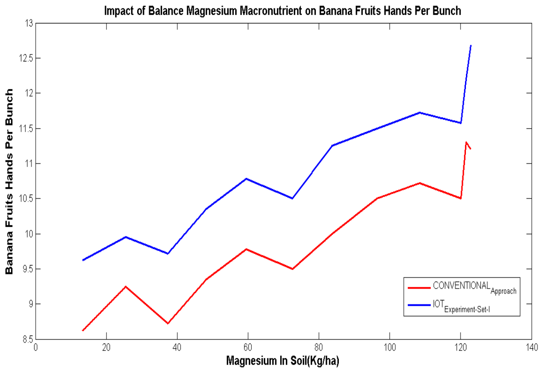

Figure - 6: Improvement in Hands/Bunch with respective Magnesium Macronutrient Rate (Kg/hector).

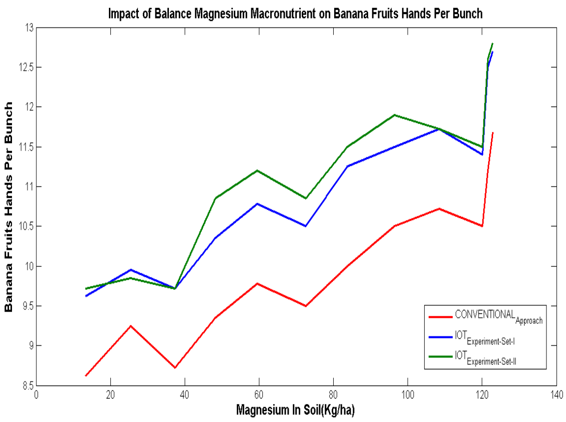

Figure – 7 : Improvement in Hands/Bunch with respective Magnesium Macronutrient Rate (Kg/hector).

Therefore, in this research experiment we proposed how to measure and supply the balanced Magnesium, Calcium and Sulfur macronutrients using our proposed agriculture system. This proposed system is helping farmers to take right decision so that all required macronutrients were properly balanced and maintained in real time banana field and it results to achieve the optimum yields of banana fruits. In Figures 6 and 7 we are presented how the Magnesium (Mg), Calcium (Ca) and Sulfur (S) macronutrients are helping to increase the various yield parameters like Banana Wight (Kg), Hands/Bunch and Fingers/Bunch with respective Magnesium Macronutrient Rate (Kg/ha).

Table 1: Improvement of Various Yield Parameters Due to Balanced Potassium Rate using Proposed NPKBANNTEX Plantation Method

Yield Parameters	Conventional Plantation Method	Plantation Using IoT Method			% Increase			Average % Increase
		SET-I	SET-II	SET-III	SET-I	SET-II	SET-III	
Bunch Weight (Kg)	29.4	32.90	35.85	38.80	3.50	6.40	9.4O	6.45
Fingers/Bunch	13.9	16.50	20.20	25.30	2.60	6.30	11.40	6.76
Hands/Bunch	9.2	10.3	10.9	11.8	11.95	18.47	28.25	19.55

Due to space constraint, it is not feasible to present all graphical experimental results so that results in Table 1 clearly indicate the significant increase in banana yield parameters like Bunch Weigh (Kg), Fingers/Bunch and Hands/Bunch due to balanced Magnesium, Calcium and Sulfur supply with the help of our proposed IoT method over the conventional method. The average percentage increase is 6.45 %, 6.76% and 19.55% in Bunch Weight (Kg), Fingers/Bunch and Hands/Bunch respectively in IoT based Precision agriculture System for banana crops.

V. CONCLUSION

In this research work initially we have carried out a detailed literature review on various approaches of precision monitoring system using Internet of Things (IoT). In our proposed Precision Agriculture System in which we used new advance technologies like Wireless Sensor Technology and Internet of Things, we design and implemented the system in which various sensors are selected by considering the required technical specifications. Advanced sensors are used to measure the different parameters like change in weather, temperature, humidity, moisture changes in soil, soil quality, fertility of soil, various weeds, level of water, magnesium,

calcium , sulfur and nitrite content in soil, ground water quality, crop growth, pest detection, crop on line monitoring, animal intrusion into the field and so on. In this research work our main focused is on three macronutrients Magnesium (Mg), Calcium (Ca) and Sulfur (S) for banana crops. With the help of our precision agriculture system, we sense, measure, control, automate and balance the micronutrients required to banana plants. Balance supply of Magnesium, Calcium and Sulfur
Macronutrients reduces moisture stress and further it helps to uptake the all micronutrients and removes the deficiencies effects in banana fruits. There is significant increase in banana yield parameters like Bunch Weigh (Kg), Fingers/Bunch and Hands/Bunch due to balanced Magnesium, Calcium and Sulfur supply with the help of our proposed IoT method over the conventional method. At the end, it can be concluded that in every situations the WSN and IoT approach is found to be perform better than conventional method. Therefore System using IoT and WSN is definitely a better approach for the precision agriculture for banana crops.

REFERENCES

1. C. XianYi, J. Zhi Gang, Y. Xiong, "Design of Tropical crops pests monitoring system based on wireless sensor network", Consumer Electronics, Communications and Networks (CECNet),2nd, 2012.
2. N. Kaewmard, S. Saiyod, "Sensor Data Collection and Irrigation Control on Vegetable Crop Using Smart Phone and Wireless Sensor Networks for Smart Farm", IEEE Conference on Wireless Sensors (ICWiSE), , Subang, Malaysia, October, 26-28 2014.
3. Miss. Lina Desai, R.P Singh and D.G Khairnar, "Monitoring of Various Crucial Parameters and Control of Salinity Damage in Banana Crop (Banntex) using WSN and IoT", International Journal of Recent Technology and Engineering, ISSN:2277-3878, Elsevier, Scopus, Published by Blue Eyes Intelligence Engineering and Science Publication, IJRTE, Volume -8, Issue-6, March 2020.
4. W. Chieh Taia, Y. Chuan Tseng, I. Chiang, Y. Sin Lin, W. Yaw Chungb, K. Wei Wu, Y. Han Yeh, "Development of a Multi-parameter Plant Growth Monitoring and Control System for Quality Agriculture Application '',Proceedings of the IEEE International Conference on Applied System Innovation
5. IEEE-ICASI - Meen, Prior & Lam (Eds), 2017.
6. S. Wan, "Research on the Model for Crop Water Requirements in Wireless Sensor Networks", International Conference on Management of e-Commerce and e-Government, pp. 234 – 237, 2012.
7. M. I. Alipio and N. Michael C. Tiglao, "Towards A Taxonomy of Cache-based Transport Protocols in Wireless Sensor Networks", IEEE Instrumentation and Measurement Society, 2017.
8. M. Culman, M. T. Jesus, C. Bayona, C. Miceli de Farias, "PalmNET: an open-source wireless sensor network for oil palm plantations",IEEE International Conference on Networking, Sensing and Control, 2017.
9. S. Parvin_, A. Gawanmeh, S. Venkatraman, "Optimised Sensor Based Smart System for Efficient Monitoring of Grain Storage", IEEE International Conference on Communications Workshops (ICC Workshops), 2018.
10. J. Huchtkoetter,A. Reinhardt, U. Kulau, "PULSEHV: Opportunistic Data Transmissions over High Voltage Pulses for Smart Farming Applications", IEEE International Conference on Distribute
11. S. Ruengittinun, S. Phongsamsuan, P. Sureeratanakorn, Applied Internet of Thing for Smart Hydroponic Farming Ecosystem (HFE)", IEEE 10th International Conference on Ubi-media Computing and Workshops (Ubi-Media),2017.
12. B. Bhanu, R. Rao, J.V.N. Ramesh and M. Ali hussain, "Agriculture Field Monitoring and Analysis using Wireless Sensor Networks for improving Crop Production", Eleventh International Conference on Wireless and Optical Communications Networks (WOCN) , 2014.
13. R. F. Maia, and A.L. Tran, "Precision Agriculture Using Remote Monitoring System in Brazil", 987-1-5090-6046-7/17, IEEE, 2017.
14. U. Shafi, R. Mumtaz, J. G. Nieto, S. A. Hassan, S.A. Zaidi and N. Iqbal, "Precision Agriculture Techniques and Practices:From Considerations to Applications", Journal of Sensors, 19, 3796; doi:10.3390/s19173796, 2019.
15. R. Kamath, M. Balachandra, and S. Prabhu, "Raspberry Pi as Visual Sensor Nodes in Precision Agriculture: A Study", IEEE Access , Multidisciplinary Rapid Review Open Access Journal, Volume 7, pp. 45110 - 45122, 2019.
16. K. P. Seng, L. M. Ang, L. M. Schmidtke, and S. Y. Rogies, "Computer Vision and Machine Learning for Viticulture Technology", IEEE Access, Multidisciplinary Rapid Review Open Access Journal, Volume 6, pp. 67494-67510, 2018.
17. R. Khan, I. Ali, M. Zakarya, M. Ahmad, M. Imran, and M. Shoaib, "Technology-Assisted Decision Support System for Efficient Water Utilization: A Real-Time Test bed for Irrigation Using Wireless Sensor Networks", IEEE Access, Multidisciplinary Rapid Review Open Access Journal, Volume 6, pp. 25686 -25697, 2018.
18. F. Viani, M. Bertolli, M. Salucci, and A. Polo,"Low-Cost Wireless Monitoring and Decision Support for Water Saving in Agriculture", IEEE Sensors Journal, Vol. 17, No.13, pp. 4299 – 4309, JULY 1, 2017.
19. P. Abouzar, D.G. Michelson, and Maziyar Hamdi, "RSSI-Based Distributed Self-Localization for Wireless Sensor Networks Used in Precision Agriculture", IEEE Transactions On Wireless Communications, Vol. 15, No. 10, pp.6638 – 6650, October 2016.
20. F.S. Melton, L.F. Johnson, C.P. Lund, L.L. Pierce, A. R. Michaelis, S. H. Hiatt, A. Guzman, D. D. Adhikari, A. J. Purdy, C. Rosevelt, P. Votava, T. J. Trout, B. Temesgen, K. Frame, E. J. Sheffner, and R. R. Nemani, "Satellite Irrigation Management Support With the Terrestrial Observation and Prediction System: A Framework for Integration of Satellite and Surface Observations to Support Improvements in Agricultural Water Resource Management", IEEE Journal Of Selected Topics In Applied Earth Observations And Remote Sensing, Vol. 5, No. 6, pp. 1709 – 1721, December 2012.
21. B. Wang, X. Deng, W. Liu And L.T. Yang, H. C. Chao, "Confident Information Coverage In Sensor Networks For Field Reconstruction", IEEE Wireless Communications, pp. 74 – 81, December 2013.
22. Y. Kim, R. G. Evans, and W. M. Iversen, "Remote Sensing and Control of an Irrigation System Using a Distributed Wireless Sensor Network", IEEE Translations On Instrumentation and Measurement, Vol. 57, No. 7, pp. 1379 – 1387, July 2008.
23. W. Qiu, F. Wang, L. Dong, H. Yan, "Design of Intelligent Greenhouse Environment Monitoring System Based on ZigBee and embedded technology", IEEE, 978-1-4799-4756, 2014.
24. L. Dan, C. Xin, H. Chongwei, J. Liangliang, "Intelligent Agriculture Greenhouse Environment Monitoring System Based on IOT Technology", International Conference on Intelligent Transportation, Big Data & Smart City, pp.487 – 490, 2015.

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