Monitoring of Various Crucial Parameters and Control of Salinity Damage in Banana Crop (Banntex) using WSN and IoT

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

Abstract*— In India 60 percent of total cultivated land is fully dependent on rain and if there is less than average rain fall than it results into significant reduction in the overall agricultural production and it leads heavy losses to farmers and ultimately it affects the overall gross domestic production of India. Banana is an important fruit and it is one of good cash crop in India. In this research work, our aim is to design and implement Banana Crop System (Banntex) to sense crucial parameters and early detection of diseases and control using Wireless Sensor Networks (WSN) and Internet of Things (IoT). To implement Banntex we uses advancement of new technology like Internet of Things (IoT), Sensors development and Improved Wireless Sensor Networks, we can design and developed Precision Agriculture systems in which various sensors are used to measure the different 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, fertility of soil, ground water quality and crop growth. Based on the measured parameters this system can be used to control and automate the farming processes. This precision system empowers farmers to keep updated, early detection of soil parameters and take necessary steps to improve it further. It results to improve the biomass, roots and overall growth of banana crops and finally it increases productivity and improved quality of farming with minimum manual tasks. Experimental results will show the significant improvement in the Banana crop production and Quality of Banana Fruit using our proposed Banntex System.

Keywords*—Monitoring System, Banntex, Wireless Sensor Networks, Parameters, soil temperature, relative humidity, water potential of banana field, pH value of soil, Electric conductivity of soil, salinity of banana field soil, Moisture changes in soil, Cloud Database Server, Banana Crops, Productivity.

I. INTRODUCTION

Now a day due to WSN and IoT, the precision agriculture technologies are taking front row seats in agriculture research [1, 2, 3, 4, 5 and 6]. 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 [6, 7, 8, 9, 10, 11, 12 and 13].

In this research, we build and develop of precision agriculture system for monitoring different parameters and uses of it to take necessary action so that it improves the growth of Banana Crops and results into significant improvement of banana crop yields [14, 15, 16, 17, 18, 19 and 20]. 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 to take necessary steps to control and automation of Precision Monitoring System of Banana Crop (Banntex) using WSN and IoT.

II. PROBLEM DESCRIPTION AND IMPORTANCE OF SOIL PROPERTIES AND VARIOUS PARAMETERS FOR BANANA CROPS GROWTH

In this research work, we formulate the problem and discussed the importance of various parameters and banana field properties. 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 Banntex system using IoT. But farmers must be aware and they need precision parameter monitoring system to arrive at the correct decisions regarding required nutrition's 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, 23 and 24]. 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. Saline solid, calcareous soils are not suitable for banana crop cultivation [25, 26, 27 and 28]. If soil contains more salt or water it causes the stress and this salinity stress causes thin, stunted, marginal leaf chlorosis and deformations in banana fruits. There is significant reduction in banana crop and root biomass due to salinity in soil. The root growth of banana crop is affects due to salinity in soil and afterwards stress is visible [29, 30, 31 and 32]. Figure 1 shows the effect of soil with more salinity in banana crops.

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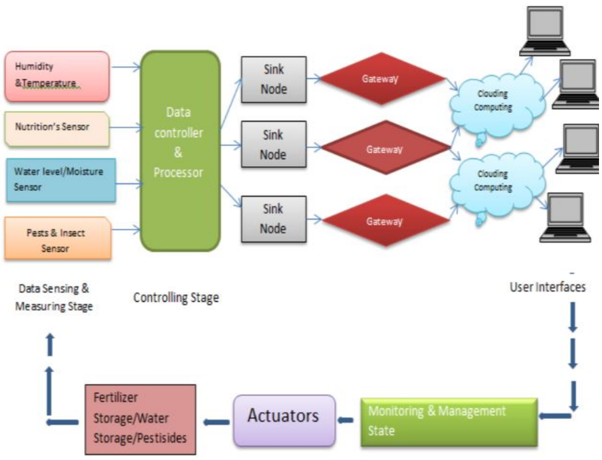
Figure–1: Soil with More Salinity Starts Damages in Banana crops.

There are many conventional or traditional methods for measuring and evaluating status of soil properties and 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 salinity and other contents quickly. In our proposed method we can overcome all these demerits [33, 34, 35, 36, 37 and 38]. In this research work, we developed Precision Monitoring System for Banana Crop Using IoT and WSN (Banntex). A soil which is neither too acidic nor too alkaline, rich in organic material with balance salinity 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.

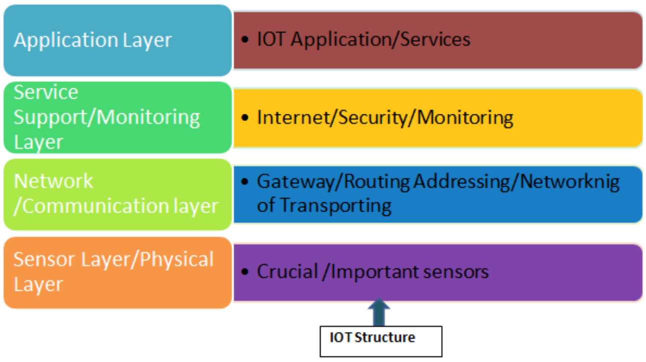
III. BANNTEX SYSTEM BLOCK DIAGRAM

Banntex 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 Banntex 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 Banntex 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 Banntex. 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 nutritional deficiencies if any and supply the balanced fertilizers to make crops more and more healthy and produces better fruits or food production with excellent yield. Figure - 2: Structural Diagram of Precision Monitoring System of Banana Crop (Banntex) Using IoT and WSN.



Figure–2: Structural Diagram of Precision Monitoring System of Banana Crop (Banntex).

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 Banntex 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. 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. This indeed helped them to improve their economy and livelihood of people. Wireless sensor networks, Internet of Things and precision agriculture are at the center of these advance technologies [18, 19, and 20].



Figure–3-(a)

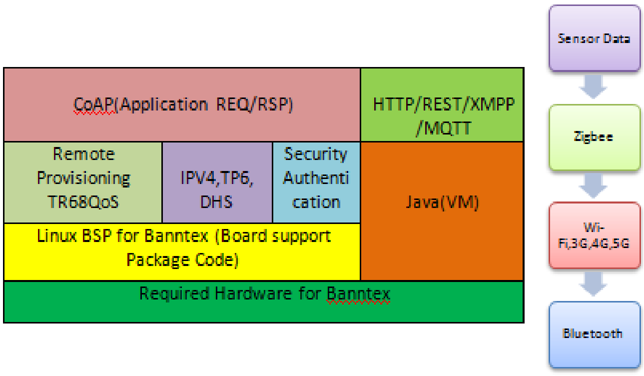


Figure 3-(b)

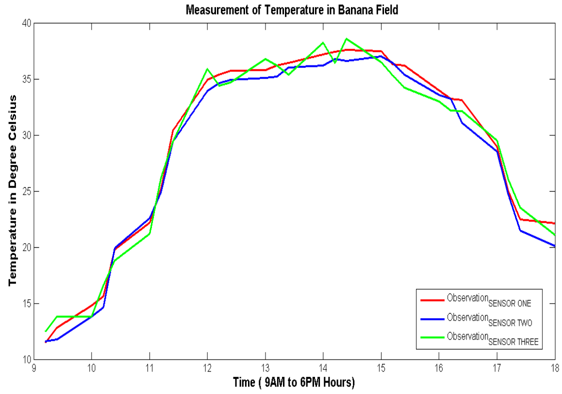
Figure 3: (a & b) Block Diagram of Hardware and Software Architecture of Banntex Using Wireless Communication Protocols

IV. EXPERIMENTAL RESULTS AND ITS ANALYSIS

In this research, our aim is to increase the productivity of banana fruits (Production Yield) with the help of proposed improved precision agriculture system (Banntex). Initially we focused on most important parameters, like 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. Our 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.

Subsection – Iv.I Measurement Of Temperature And Relative Humidity Of Real Time Banana Field

In our experimentations, initially we focused on two most important parameters, like temperature and relative humidity of real time banana fields. Banana Field Monitoring and Measuring: 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 filed temperature and relative humidity. Every sensor node is monitoring temperature and relative humidity moisture 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.



Figure–4: Measured Temperature from Various Sensors from Three Different Locations in Real Time Banana Field.

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 temperature and relative humidity. 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.

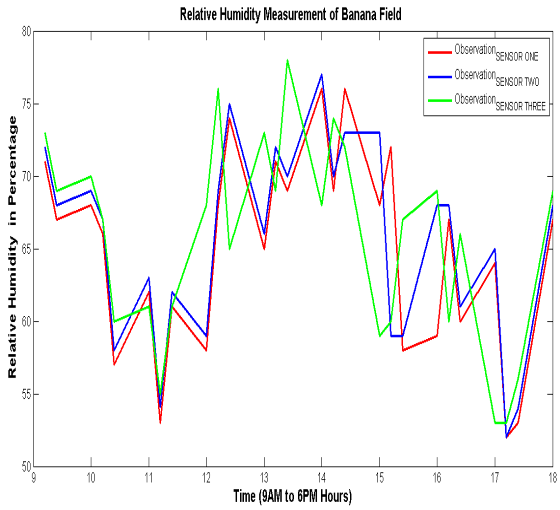


Figure – 5: Relative Humidity Measurement Using Three Sensors in Real Time Banana Field.

Various Measured values of temperatures and relative humidity in real time banana field are presented in Figure 4 and Figure 5. There are many sensors to measure the temperature and relative humidity values from 9 am to 6 pm at regular interval of time. 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.

Subsection – Iv.Ii Measurements Of Soil Properities In Real Time Banana Crop

In these research experiments, we used various sensors to measured the different 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, fertility of soil, ground water quality and crop growth in field.

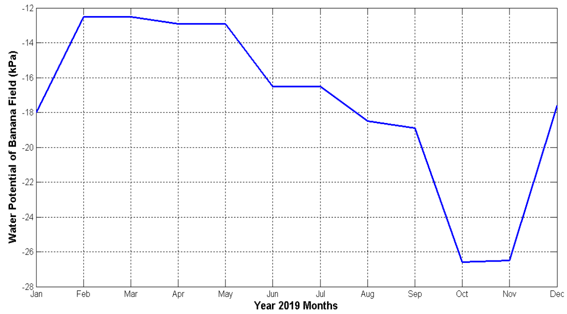


Figure – 6: Measurement of Water Potential of Banana Field Soil (kPa) for the Duration of January 2019 to December 2019.

Our Banntex system using IoT allows us to measure the soil properties in real time and we recorded all the results. Sensors used to measure Water Potential are buried under the soil in banana field for the period of twelve months (from January 2019 to December 2019). The other parameters like Air temperature and other factors are also used as references.

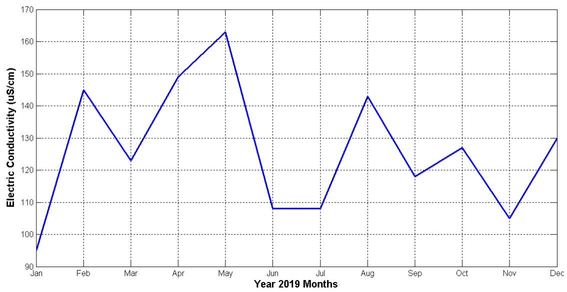


Figure – 7: Variation in Measured Electric Conductivity (uS/cm) of Banana Field Soil (January 2019 to December 2019)

Figure 6 and 7 demonstrated the measurements and variations of Water Potential of Banana field soil (kPa) and Electric Conductivity (uS/cm) of banana field soil from January 2019 to December 2019. These measured parameters results help us for the measurement of various soil properties. Measured soil properties are further useful for various precision agriculture and banana crop cultivation decisions. Variations in these parameters are because of many events like rain fall, irrigation, fertilization and we can correlate these changes for further decisions and actuation purposes with the help of our proposed Banntex System using IoT.

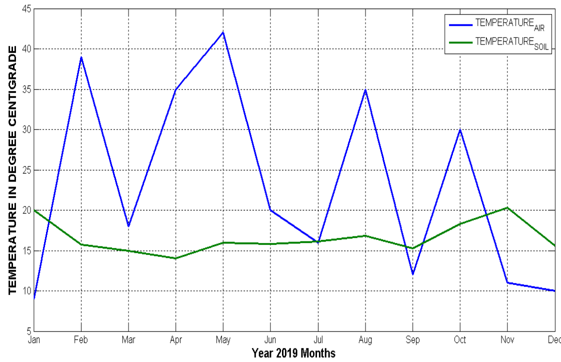


Figure – 8: Measured Air and Soil Temperature for one Year Duration (2019)

Figure 8: shows the example of measured air temperatures and soil temperatures of banana field for duration of complete one year 2019. From the presented example we can conclude that, variations in measured air temperature are much higher than the measured soil temperature. It is because of banana fields soil heat capacity is relatively higher than air and there are variations in soil temperature due to water content in soil changed due natural events like rain or hot summer and artificial activities like irrigation and fertilization by farmers.

Subsection – Iv.Iii Measurements Of Ph Value And Comparasion Of Effect Of Salinity Soil In Banana Crop Biomass Using Banntex.

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%

In India, four months of monsoon June to September with an average rainfall is most important for vigorous vegetative growth of banana plant. Figure 9 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.

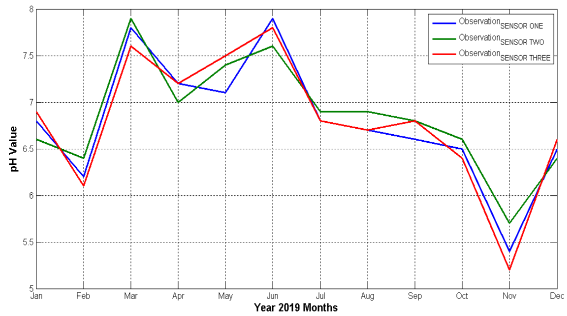


Figure – 9: Example of pH value Measurement of Banana Field Soil from January 2019 to December 2019.

Since in real-time Banana plants needs correct soil parameters 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 Banntex method using IoT and WSN and experimental results are compared with conventional method. As shown in graphical results we conducted different sets of experiments, using conventional method and using our Banntex method. We observed effect of salinity soil (variation from 0 to 12 [EC ds/m]) in banana crop biomass (Dry matter relative 100% =0.9 ds/m).

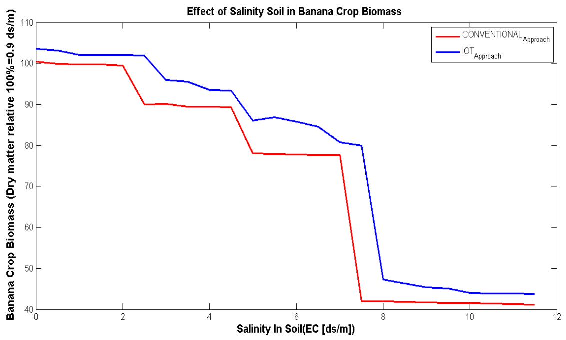


Figure – 10: Comparison of Effect of Salinity Soil in Banana Crop Biomass using IoT Banntex System and Conventional Approach.

As shown in Figure 10, banana plants biomass is more in case of Banntex using IoT and WSN method compared to conventional method. There is Banana crop and root mass reduction because of increase in salinity in soil. Salinity makes reverse impact on root growth of banana plant afterwards stress it is clearly visible. Proposed Banntex method also helps to reduce stress in banana plant and it clearly visible.

V. CONCLUSION

Due to advancement of new technology like Internet of Things (IoT), Sensors development and Improved Wireless Sensor Networks, we can design and developed Precision Agriculture Systems named as Banntex in which various sensors are used to measure the different 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, fertility of soil, ground water quality and crop growth the banana field. Experimental results of the proposed Banntex system using IOT & WSN indicated that, the performance of Banntex system is much better than conventional method. There is significant increase in the root growth and crop biomass of banana plant. Banntex method also helps to reduce stress in banana plant and it clearly visible. Research Experiments have illustrated that, there is significant improvement in banana plants yield using Banntex method compared to traditional method. The proposed system is helping farmers to take a decision at right time so that they can properly balanced soil properties and maintain in real time banana field and it results to achieve the optimum yields of banana fruits. At the end, it can be concluded that in every situations the Banntex approach is found to be perform better than conventional method. Therefore Banntex using IoT and WSN is definitely a better approach for the precision agriculture.

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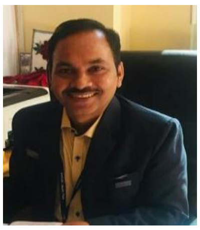

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