THE INTEGRATION OF INTERNET OF THINGS (IOT) AND SOIL NUTRIENTS MONITORING TO ENHANCE ORGANIC FARMING: A CASE STUDY OF CASAD ENTEPRISE FARM

Samuel Ibbih Mamman[1] & John Bosco Lubega[2]

1-St. Lawrence University, Uganda Email: samuelibbih@gmail.com
2-St. Lawrence University, Uganda, Email: agendalubega@gmail.com

ABSTRACT

OECD-FAO, 2016, A vast fraction of population of Africa considers agriculture as their primary occupation. Production of crops plays an important role in our countries. Bad quality crop production is often due to either excessive use of fertilizer or using not enough fertilizer. For efficient crop growth, it is essential to measure the level of nutrients present in the soil. The proposed system of IOT enabled soil testing is based on measuring and observing soil parameters. This system lowers the probability of soil degradation and helps maintain crop health. NPK sensor used in the monitoring system nutrients of the soil. The data sensed by these sensors is stored on the cloud and analyzed based on which suggestions for growth of the suitable crop is made. A Wi-Fi module interfaced with Arduino is used for displaying test result data along with a list of particular crops suitable for the tested soil. A web portal is also created which gives information about the fertilizer(s) required for their crops. This article presents a study of soil and the relevant parameters involved in the prediction of suitable crops to avoid the problem of soil infertility and to improve the quality of crops. This system is designed by keeping the needs of farmers in mind which results in its capacity to make suggestions via the system designed.

In conclusion of the study, a scheme has been successfully developed to detect soil nutrients quality and provide information on the quantity of nutrients and further the nature of organic farming that could be used in upcoming generation.

Keywords – Sensor, Internet of things, Soil Testing, Nutrient Detection, Organic farming, NPK

BACKGROUND

Over centuries, the development of agriculture/farming contributed to the rise of civilizations that is climacteric to economic growth (Raj Patel 2013). Abiotic components including topography and soil are the factors influencing production of plants and crops. Today, agriculture occurs on large scale but the agrarian driven growth, poverty reduction, and food security are at stake. The climate change could cut crop yields, especially in the world's most food insecure regions. All plants require a balanced supply of nutrients for its growth. Among all the nutrients for plant growth are nitrogen, potassium and phosphorous as the primary macronutrients required by the plants for robust growth (FAO, 2015).

The acidity of the soil or pH is key factor in ensuring healthy plant growth. Specific plants vary in the soil pH they prefer universally. Hence, soil monitoring is the basic procedure for farming. The unprecedented crop yield due to unfavorable weather conditions and infertile soil led the farmers to face financial problem causing many suicidal cases across the world (LA Msimbira • 2020). So to minimize such drawback there is a need of structured and balanced framework which is helpful for developments of agriculture field.

Soil nutrient monitoring system is to master the nutrient status of the bare ground, and quickly extract the information of farmland nutrient.
Soil nutrients are categorized into macronutrients required for sustained plant health such as Nitrogen (N), Potassium (K), Phosphorus (P), Carbon(C), Hydrogen (H), Oxygen(O), Calcium (Ca), Magnesium(mg), & Sulfur (S) and micronutrients also essential to plants development and growth such as Chlorine (Cl), Iron (Fe), Boron(B), Manganese (Mn), Zinc(Zn), Copper(Cu), Molybdenum(Mo), Sodium(S), Silicon(Si) & Nickel (Ni).

The absence of the above nutrients result to loss of money by farmers, under development of plants and a decrease in yield and nutritional values of crops will cause nutrients imbalance, directly affecting food production, quality and food security.

Table 1: showing macronutrients and there required ranges.

Element	Symbol	Primary forms used by plants	Plant Content (%) PPM
Nitrogen	N	NH4+ , NO3-	0.5-5
Phosphorus	P	HPO42-, H2PO4-	0.1-5
Potassium	K	K+	0.5-5
Calcium	Ca	Ca2+	0.05-5
Magnesium	Mg	Mg2+	0.1-1
Sulphur	S	S042-	0.05-0.5

Table 2: showing micronutrients and there required ranges.

Element	Symbol	Primary forms used by plants	Plant Content (%) PPM
Iron	Fe	Fe3+, Fe2+	50-1000
Manganese	Mn	Mn, Mn2+	20-200
Zinc	Zn	Zn2+	10-100
Copper	Cu	Cu2+	2-20
Boron	B	H3B03 (Boric acid)	2-100
Molybdenum	Mo	Mo, Mno42-	0.1-10
Chlorine	Cl	Cl-	100-10,000

Internet of Things (IoT)

(M Dhanaraju • 2022) Internet of Things (IoT) is a new technology that allows devices to connect remotely to achieve smart organic farming.

The accelerated use of nutrients for crop production and other human activities has significantly impacted and modified the global nutrient cycles in the planet, especially for N and P (Sutton et al., 2013; Steffen et al., 2015). Despite the critical role played by nutrients such as N, P, and other macro and micronutrients, their significance in global challenges such as climate change and contamination has gotten far less public attention than other drivers of environmental change including CO2 and non-CO2 emissions (Sutton et al., 2013).

Organic farming enhances soil fertility by improving its physical, biological and chemical properties.

IoT in soil nutrient promotes precision which enables farmers to remotely monitor the plants.

1. Internet of Things and smart farming helps agricultural processes as the automation of sensors has made organic farming workforce more efficient. (Liakos, K.G; Busato, P. 2018, 2674).
2. The technologies convert traditional farming methods to automatic devices causing revolutions in agriculture.
3. Technologies has altered the way farming is conducted and techniques have been transformed by the Internet of Things.
4. These innovations increase the accuracy and timeliness of decisions taken and improves organic farm productivity.
5. Internet of Things and smart agriculture and monitoring improve the spatial management practices that increase organic production and avoid the excess use of fertilizers and pesticides.

Soil Nutrients based on Internet of Things has many advantages in all agriculture processes in real time including irrigation, plant protection, improve product quality, fertilization, disease prediction and control. The benefits lies in its collections of real time data on crops, the precise assessment of soil and crops, remote monitoring by farmers, and maintenance solutions.

Farmers need accurate information about soil nutrient content if they are to apply the correct soil analysis. Traditional laboratory testing is however laborious, taking weeks to complete.(DS Simbeye • 2020). On-the-go sensors have the advantage of providing non-destructive and rapid quantification of soil variability to enable precision soil nutrient management and monitoring. The prospects of sensors for real-time mapping of important soil nutrients properties to facilitate precision soil nutrient management and monitoring are promising. However, the possibility of on-the-go sensor fusion that would allow simultaneous spatial variability quantification of important crop-soil properties under diverse growing conditions is still unclear. Increasing population growth coupled with the increasing risks associated with climate change inevitably requires a commensurate increase in agricultural productivity. Key to this challenging task is to ensure sustainable soil productivity while maintaining high crop yields and reducing environmental pollution. To this end, the implementation of sensor technologies for soil nutrient management and monitoring is a step in the right direction.

Components of soil nutrients

1. NPK Sensor: **this sensor** is suitable for the detection of macronutrients and micronutrients such as **nitrogen, phosphorus, potassium**, zinc and copper in the soil. The sensor is deepen in the soil for it to get the nutrient reading, helping to determine the soil fertility.

2. [illegible] th send & receive data. Its working frequency is **2.4GHz**. The modules when operated efficiently can cover a distance of 100 meters.

3. **Arduino Microcontroller Board**: The board are equipped with sets of digital and analog input/output (I/O) pins the may be interfaced to various expansion boards, breadboard and other circuits. The board can be programmed using C, C++, Python and (API) Arduino Programming Language alongside (IDE) Integrated Development Environment and a command line tools developed in Go.

4. **LCD Display**: Display the value of soil reading in percentage.

RESEARCH QUESTIONS

1. What is the relationship between IoT, soil nutrients and organic farming?
2. How to improve and measure proper soil nutrients?
3. How to design, implement an IoT and soil nutrients monitoring system to enhance organic farming?

PRESENTATION OF RESULTS, FINDINGS, DISCUSSION & RECOMMENDATION

Design is an important phase of developing any software system. In this phase, the designer outlines rules, paths, and how requirements are been transformed into a workable and functional software product that can be updated, modified, maintained and easily understood by the system users(farmers) . Designing a management system entails translating the requirements specification into a physical form which requires using different patterns to realize the intended system. The design phase is the architectural phase of the system design. The flow of data processing is developed into charts and determines the most logical design and structure for data flow and storage. System analysis and design focuses on systems, processes and technology.

Maintaining or enhancing long-term soil productivity to organic farming and Agriculture is a key provision of the National Organic Program (NOP) regulation, which states that the producer/farmer/agriculturist must: -

(a) Select and implement practices "that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion,"
(b) "Manage crop nutrients and soil fertility through rotations, cover crops, and the application of plant and animal materials," and
(c) "Manage plant and animal material applications to maintain or improve soil organic matter," but minimize "contamination of crops, soil, or water by nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances." Any soil-applied product, including composts or manures, must be produced in compliance with NOP regulations.

Nutrient management on organic farms should economically meet crop nutrient needs and avoid soil nutrient depletion, while maintaining or improving soil productivity without excessive nutrient losses. Soil nutrient availability is dependent on diverse soil chemical, physical, and biological properties, their interactions, and their interaction with the cropping system. While measurements can be made for many soil properties, crop performance is the best indicator of soil productivity. Farmers typically manage to minimize soil physical and chemical constraints to sustainable productivity through practices such as:

- Applying organic materials such as manure, compost, and bio-fertilizers to supply nutrients and maintain soil organic matter
- Growing cover crops to cycle soil nutrients and biologically fix atmospheric nitrogen. Diversifying crop rotations for more efficient recovery and physiological use.

CONCLUSION

Agriculture remains a key sector for development in every economy. Immersive technologies have the potential to support smart agriculture for increased productivity. This research has successfully developed an IoT for monitoring system which will assist farmers in gathering real-time information about diverse soils, their fertility levels, and recommending crops and fertilizers. According to the results of a number of experiments, the built IoT system is shown to be beneficial to farmers in terms of increasing crop yields. Finally, this project effort will assist farmers in making the best decision possible, resulting in increased yield and economic benefit.

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