LITERATURE REVIEW ON FERTILIZER MANAGEMENT BASED ON SENSOR TECHNOLOGY

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***Abstract*— Fertilizer usage exaggerated in worldwide, and it causes the several environmental impacts. In order to minimize the ecological factors the fertilizer management is significant. As a result of fertilizer management in the agriculture system helps to maximize crop nutrient usage expeditiously and minimize the nutrient losses via atmosphere conditions. The laboratory soil testing methodology is a standard technique for fertilizer management, which is complex and time-consuming due to extraction and pretreatment process involved. In order to boost the fertilizer management adoption of precision agriculture is significant. Therefore, implementing the various sensor techniques to map the physical and chemical properties of the soil, which result can be provided in real time or quasi-real time at the moderate price. The Most common technique, are remote sensing and a proximal sensor which is providing high-resolution data based on own attributes. Alternatively, yield map and expert systems provide the overall impact of management activities and natural conditions. As each soil sensing technology has upsides and downsides, i.e. one single sensor can't quantify all the properties of soil. This makes a corresponding single sensor platform is uncertain and complex when attempting to deploy different production setting. This drawback can be overcome by integrating multiple proximal soil sensors in a single platform. This review demonstrates the integrating the multiple proximal soil sensor technologies for detecting macronutrient and other vital soil properties in order to improve the measurement accuracy.**

***Keywords*— Fertilizer, Multisensory Fusion, Precision Agriculture, Soil Test**.

I. INTRODUCTION

The modern farming technique is named as precision agriculture or sustainable agro-management system. The main aim of modern farming technique is adopt and design agriculture management system based on low initial cost, increase the production value and develop the sustainable growth in agriculture [1,2]. The emerging precision agriculture techniques are the GIS and GPS technologies, in-field and remote sensing, mobile computing and telecommunication and more. Almost precision agriculture techniques reached most of the agro-sectors but the environmental and economical wise still unstable. In India, most of the farmers are not willing to adopt the modern farming techniques. The new techniques are unreached because of literacy and economical unstableness. Therefore, it is essential to encourage the farmers to adopt the precision techniques in their field to get the sustainable agriculture growth. Finally, the performance of the modern farming technique is measured by environmental and profitable attributes [3].

Variability influences the agriculture production and it can be categorized into six groups, they are crop, field, soil, yield, anomalous factor and management visibilities. From the above groups the soil variability is important because plant growth depends on fertility status of the soil. For obtaining sustainable crop yield, farmers must identify the nutrient deficiency and toxicity. The yield of the crops is affected by several factors as atmospheric conditions, crop injury, excess fertilizer, pesticide drift and insect infestations which may cause of nutrient deficiencies. Balanced fertilization is significant in order to improve the fertility level. The conventional method for obtaining balance fertilization is laboratory soil testing. Soil testing is mainly conducted for analysis the available nutrients status for making fertilizer recommendations [12].

The main objective of soil testing is an increase the agricultural productivity and production and minimizes the waste of nutrients. Soil testing program started in India during the year 1955-56, at the time of starting only 16 soil testing laboratories are initiated. The number of soil testing laboratories increased 1024 in 2010-11 its analysis capacity 1.07 crore samples. Over the 12 crore farm holding in a country only 1.07 crore samples are analyzed per year [16]. Most of the farmers not even analysis their soil fertility status because of laboratories delaying the given analysis report, laboratory equipment is often not calibrated and quantity of chemicals are often not supplied according to the sample analysis capacity. Based on the above reasons most of the farmer not even check their soil and use inappropriate amount fertilizers. In general, too much amount of fertilizer can cause several environmental problems. For example the Nitrogen fertilizer available in the form of urea and ammonium nitrate which is used for plant growth. Most of the nitrogen fertilizer is not absorbed by crops, it has been lost to groundwater atmosphere and surface water due to high level NO_3-N content, water becomes undrinkable [15]. Poor nitrogen fertilizer management can cause nitrate leaching and increase the emission of ozone-depleting gases i.e. N_2O, NO_X, NH_3 [13]. To overcome this drawback balanced nutrient recommendation is needed. At the same time current laboratory methods are not sufficient one, for this reason automation is urgently needed in soil testing.

II. CONVENTIONAL METHODS OF SOIL TESTING IN INDIA

The laboratory procedure of soil testing is performed by three steps they are soil sample collection, pretreatment procedure and chemical analysis. For a plant growth soil needs sixteen essential nutrients and it was divided into two groups they are macronutrients and micronutrients. The important macronutrients are Nitrogen, Phosphorus, and Potassium simply called as NPK [8]. Generally, soil testing laboratories use organic carbon to measure available nitrogen. Olsen and brays method used for available phosphorus and neutral normal ammonium acetate for Potassium. (16). National level available nutrients status is given table 1.

TABLE-1

SOIL FERTILITY RATINGS

S.NO	SOIL NUTIIENTS	SOIL FERTILITY RATINGS		
		LOW	MEDIUM	HIGH
1	AVAILABLE NITROGEN (%)	<0.5	0.5-0.75	>0.75
2	AVAILABLE P(kg\ha)	<10	10-24.6	>24.6
3	AVAILABLE K(kg\ha)	<108	108-280	>280

Other method spectrophotometer devices such as a flame photometer, ICP-OES (inductively coupled plasma atomic emission spectroscopy) and ASS (atomic absorption spectrophotometer) are widely used in standard laboratories for micro and macronutrients level detections[18]. These devices are high initial cost, size and fragility of this equipment make transportation difficult so it is not suitable for on-field analysis.

III. METERIAL AND METHODS AVAILABLE

A. Proximal Soil Sensor Or On The Go Soil Sensors

The increasing prices of fertilizer and environmental degradation while using fertilizer and pesticides are important concerns for precision agriculture. Numerous researcher and developers have attempted to develop various in-field soil sensors to measure physical, chemical and mechanical properties of soil. The most common methods of the on-the-go sensor are optical, radiometric, electrochemical, electromagnetic and electrical, mechanical pneumatic and acoustic sensors. From the above proximal sensors, electromagnetic and electrochemical sensors are most commonly used soil nutrients level measurement. Other technologies may also be applicable to improve the quality of nutrient detection near in the future.

TABLE 2

ON-THE-GO SOIL SENSOR TYPES AND THEIR APPLICATIONS

Sensor Types	Applications
Electrochemical	Soil Ph, Nitrate, Potassium
Electrical And Electromagnetic	Soil Texture (Sand, Silt, Clay), Soil Moisture Content Soil Depth Variability Cation Exchange Capacity
Optical And Radiometric	Soil Organic Matter, Soil Moisture
Acoustic	Soil Texture (Sand, Silt, Clay), Soil Bulk Density (Compaction) Soil Depth Variability (Depth Of Topsoil, Depth To Hardpan)
Mechanical	Soil Compaction, Compacted Soil Layers

Table 2 shows the proximal sensor and its corresponding application in precision agriculture. From table 2, electrochemical, electromagnetic measurement and the optical sensor are used for soil macronutrient (NPK) measurement. In optical sensor spectrometry techniques i.e. visible and ultraviolet used for Nitrogen and phosphorus measurement. For potassium measurement, the flame spectrometry or atomic absorption spectrometry techniques are used [7]. The optical sensor methods are reliable and reliable, but time-consuming, complex construction and high initial cost. So far electrochemical sensor most widely used in soil nutrient measurements.

B. Electrochemical Sensor For Soil Nutrient Measurement

For soil nutrient measurements the electrochemical sensor used and important sensor is Ion Selective Electrode (ISE) and Ion Selective Field Effect Transistor (ISFET) [17]. Standard laboratory techniques for soil nutrient measurement use different procedure and instrument to investigate the soil samples which are taken from the field and transported to a laboratory. With recent advances in using ISE for nutrient detection,which can measure directly, rapidly accurately, at low cost, at a fine scale and in real time right in the field.ISE is a transducer that converts specific ion dissolved in a solution into an electrical potential that can be measured by a voltmeter. ISE and ISFET both required recognition element i.e. Ion Selective Membranes (ISM). Each nutrient having separate ISM this is integrated with a different reference electrode. ISE and ISFET have used soil nutrient detection in two ways (I) flow injection analysis system (II) vehicle-based soil sensing system [9]. ISFET has several advantages over ISE such as fast response, small dimension, low output impedance, high signal to noise ratio and integrates the multisensory into a single chip [5]. Hak-Jin Kim et al. developed a site specific crop management system for monitoring the soil macronutrients within the field [8]. A Prototype of soil Nitrate mapping system (SNMS) was developed to measure nitrogen ($N0_3$-N) content in the soil. It has been demonstrated that soil NO_3-N measurement using the SNMN can be obtained rapidly, on the fine scale with lab grade accuracy [10]. So far, most soil nutrient detection methods can only measure one target ion by using conventional electrochemical measurement due to an ion selective membrane, ISE selectively responding to one target ion. V.I. Adamchuk et al. (1999) developed a direct soil measurement (DSM) using ion-selective electrodes (ISEs) for on-the-go mapping of soil pH. DSM was implemented by combination ion-selective electrodes (ISEs) were used to determine ion activities of H+, K+, NO3−, and Na+ in naturally moist soil samples. Albeit no effective technique to rapidly measure soil phosphorous content has been produced right now, on-the-go measurements of soil pH, available potassium, residual nitrate-nitrogen, and sodium content have been attempted [6]. As every soil-sensing technology has strength and weakness and no single sensor can measure all soil properties. In order to enhance the accuracy of precision agriculture, Multisensor concept is essential. Multisensor fusion provides the number of operational benefits over the single sensor such as robust operational performance, increase confidence as independent measurement is made on the same soil, extended attribute coverage, and increase the dimensionality of the estimation space.

IV. SENSOR FUSION TECHNIQUES IN PRECISION AGRICULTURE

The main inadequacy of any proximal sensor in precision agriculture is that crop growth is significantly disrupted by various soil physical parameter, they are soil water content, mechanical strength, soil nutrient level and electrical conductivity of the soil. This constitutes a corresponding decision-making strategy uncertain and complex when to endeavor to deploy different production setting. Furthermore, the validity of single sensor estimation is often not as much as perfect because currently available sensors technology can react more than one basic parameter of interest. Utilizing a combination of diverse sensing techniques and incorporating the subsequent data in which providing more accurate estimates, robustness and improve the adaptability of the sensor [4]. This approach is called as multisensor fusion, which integrates the sensor data and data derived from different sources. For instance, crop canopy reflectance sensors have emerged as a new tool for localized prediction of crop biomass and nitrogen uptake by crops. These sensors can be influenced by multiple stressors such as water or nitrogen insufficiency, a reflectance of inherent soil and size of the crops. Multisensor fusion approach that incorporates canopy reflectance with other sensors to estimate the crop size and soil parameters can possibly enhance the measuring accuracy. Sun yurui was developed a novel technique of sensor integration. The triple sensing cell simultaneously measuring the soil water content, mechanical strength and soil electrical conductivity[14]. Mojtoba Naderi developed triple sensor fusion system for on-the-go measurement of soil compaction. In this study, a novel sensor fusion is proposed that combines a single probe horizontal penetrometer, die-electric type soil water content and gamma-ray sensor used for simultaneously measuring the soil compaction, soil water content and clay content[11].

V. OPPORTUNITY AND CHALLENGE IN SENSOR FUSION IN SENSOR FUSION

A plethora of sensors are accessible for in-field soil estimation in precision agriculture. For this circumstance incorporate these sensors, towards adding more accurate as well as reducing cost is more imperative. Therefore a paradigm shift from a single sensor to a multisensor based system is urged. The potential advantages of integrating and fusing information from multiple sensors in the agriculture sector, a fusion of redundant information can reduce overall uncertainty and thus serve to increase the accuracy compare to the single sensor system, in less time and at the less cost.

However, the multisensor platform is difficult to implement in an agricultural setting due to constrain such as cost and durability. Generally, small- scale farmers are not interested to adopt the new and expensive technology in their farmlands. Because the reliability of sensor system influenced by a several field condition including dust, moisture and vibration ext. apart from above issues some other issues generated in fusion or integration process, they are data imperfection, failures and spurious data, data correlation, data alignment, data association, operational timing, static vs dynamic phenomenal and data dimensionality. A majority of these issues arise from the imperfection of sensor data at the time of fusion, the varied sensor technologies and nature of application environment in the field. Among the other, issue that started out in fusion algorithm i.e. The fact that there is no perfect algorithm present under all conditions. Therefore, need to keep multiple sensor functions simultaneously magnifies this issues. To balance the advanced technology demands, the sensor fusion technique must improve the all above limitation. Over the past two decades of research results shows the benefit of multisensor integration in agricultural sectors. Therefore, find out the proper integration of different sensor for a given application is the future scope of research in precision agriculture.

VI. CONCLUSION

The benefits of electrochemical sensor are stimulating the interest of their application in soil nutrient detection. For in-field soil nutrient measurement, electro chemical sensor has a potential for automatic multi-target measurement. But electrochemical faced difficulties in the reliability of the system and apart from macronutrient it becomes not suitable for other essential nutrient measurements. One of the recent advanced technologies is sensor data fusion. A sensor fusion approach that integrates multiple sensors to get better field management practices. Because inappropriate field management will cause several environmental risks as well as farmers economic factors. Using this method to treat the complex soil testing procedures with simpler methodology at lower cost, in future much more proposals will appear in agriculture using sensor fusion techniques.

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