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Remote Sensing for Precise Nutrient Management in Agriculture †

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Abstract: Agricultural sustainability and food security are adversely affected by nutrient deficiency in the soil that in turn reduces crop yield. To restore soil fertility, precision agriculture (PA) techniques are highly encouraged. The PA techniques include the use of integrated sensors, information systems, better-quality machinery, and informed management to improve productivity. The quality and quantity of agricultural products can be improved by precision farming. The use of remote sensing is a nondestructive technique that facilitates the application of PA. The nutrient use efficiency of crops can be improved by using PA technology. In this regard, various remote sensing techniques including hyperspectral remote sensing, visible light remote sensing, and the back-propagation neural network (BPNN) model combined with ordinary kriging (OK) known as BPNKOK are currently being employed to improve soil nutrients management. These techniques assist in non-destructive monitoring of plant growth and hence aid in sustaining crop yields.

Keywords: precision agriculture; remote sensing; nutrient management; soil fertility

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1. Introduction

Precision agriculture (PA) is a farming system, based on integrated information and farm production, that helps us to enhance the production of farms and ensure site-specific nutrient application. The continuous use of chemical fertilizers has resulted in detrimental impacts on soil quality and the overall environment. The use of PA technology offers many advantages such as those related to the economy, environmental sustainability, and overall society [1]. Over the last 10 years, global investments and improvements in PA technology have increased dramatically [2]. PA has played a role in different fields such as sustainability, quality of several crops, productivity, protection of the environment, rural–urban agriculture development, and farm food quality [3].

The depletion of soil fertility and productivity is another main concern in the growing world. The deficiency of different nutrients including nitrogen, sulfur, potassium, zinc, and boron is the main problem in the soil. In Asian soils, nitrogen deficiency is more common. In some areas, potassium deficiency is also increasing. Sulfur is found deficient in more than 40% of samples. The deficiency of zinc in soil is up to 49%, about 12% of soils do not possess the required amount of iron and 5% of soils are deficient in copper and manganese. Moreover, 33% of boron-deficient soils were observed in 36,800 samples of soil. The efficiency of agricultural systems can be increased by using efficient agricultural production technologies such as remote sensing. By using these techniques, information on soil fertility can be collected without disturbing its surface layer.

2. Remote Sensing Applications

Remote sensing (RS), along with other systems like GPS (global positioning system) and GIS (geographic information systems), is used to access and control the agricultural activities. RS techniques are used in agriculture to determine crop and field status such as, soil moisture contents, soil fertility status, detection of crop stress and disease-causing pests for sustainable production of crops and to improve the economic status of the country [4]. The hyperspectral images, obtained from the solar-induced chlorophyll fluorescence (SIF), are used to estimate the plant nutrient and photosynthetic status [5]. Another sensor, such as vegetation indices (VI), is used for crop nutritional status valuation [6].

2.1. Role of Remote Sensing in Nutrient Management

Remote sensing is the science that involves the collection and interpretation of information or data about an object by the use of remote sensors, without making any physical contact with that objects i.e., at some distance from the earth's surface [7]. RS has importance in the classification and evaluation of crops and yield. Remote sensing is the science and art of collecting data from the earth's surface without contacting it directly [8]. It is a non-destructive technique of collecting data on the earth's surface. The information can be obtained analytically over a huge geographical area, except for the observation of a single point. RS collects data from areas that are unapproachable to humans. It is autonomous from the information collected elsewhere, in contrast to other mapping sciences like GIS and cartography. The GIS and RS techniques help in improving the nutritional status of significant agricultural areas. The use of GIS and RS can reduce the costs for farmers and enhance the efficiency of fertilizers for crops that ultimately reduce nutritional stress by using site-specific nutrient management techniques [9].

The under- and over-fertilization of soil, prominent due to the heterogeneous nature of soil, can be improved by using the standard single-rate N fertilization technique. The use of variable-rate nitrogen fertilizer (VRF) can improve the effectiveness of N fertilization [10]. This VRF technique can improve nutrient use efficiency and crop output and decrease the nutrient loss from the fields, thus controlling environmental pollution [11].

2.2. Types of Remote Sensing

Different types of remote sensing techniques are used for the fast diagnosis of crop nutrition and growth. Canopy color analysis, hyperspectral remote sensing, and visible light remote sensing are useful techniques that are widely used. These are likely to become hypothetical and non-destructive diagnostic methods for nitrogen crop nutrition in the new era due to the benefits of stable, fast, accessible, and non-destructive results, as well as the good correlation between the color parameter of the NRI canopy and N content of crop and performance index. It is claimed for non-destructive analysis of N availability and its viability to evaluate the N content and plant growth readily and in real-time [12]. To measure total soil nitrogen, soil obtainable P and K content, hyperspectral images were used with a neural network model in a back-propagation neural network (BPNN) and combined ordinary kriging (OK) (Figure 1). The application of hyperspectral imaging with the BPNNOK model has proven to be an effective technique for the detection of soil nutrients [13].

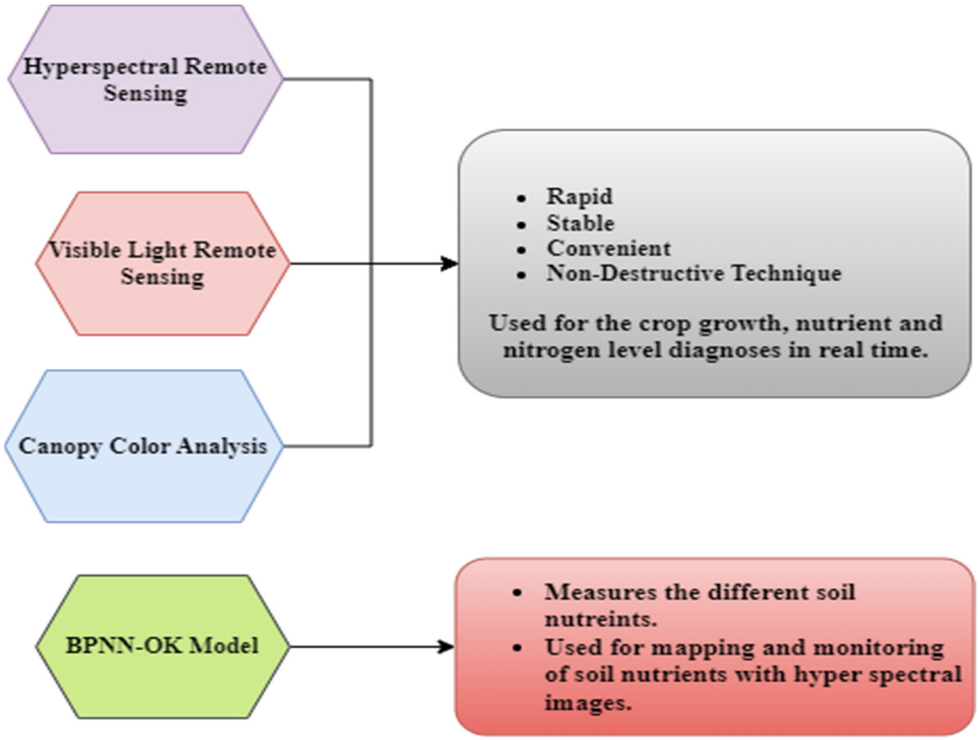

Figure 1. Types of remote sensing in nutrient management.

3. Conclusions

With the increase in the world's population and the pressure on food, there is a need to improve nutrient management through several nondestructive techniques. There are several remote sensing techniques available, such as canopy color analysis, hyperspectral remote sensing, and visible light remote sensing. In addition, the application of the BPNNOK model has been proven to be an effective technique for the detection of soil nutrients. Thus, it is concluded that the application of remote sensing is a precise technique in nutrient management that ultimately aids in improving plant growth and nutrient status.

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