Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 7, Issue 08, August -2020

# A Survey of Crop Nutrients Deficiency Detection using Machine Learning

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**Abstract** —*Agriculture is the main source of Indian economy which includes cultivation of crops and produces the food [1]. While producing a crop, nutrients play a very important role in it. Nowadays, the yielding of crops is decreasing day by day. This is due to nutrient deficiency. Farmers face the problems of nutrient deficiency and appropriate fertilizers for the producing good crops. Earlier, it was impossible for the farmers to detect the deficiency of nutrients in crops. Due to deficiency of nutrients in plants, the plants get damaged and may die [1]. But in this 21st century, the world of technology, there are various techniques available to detect its deficiency and make good cultivation of crops. Various algorithms are also used to detect nutrient deficiency in different plant such as Kappa coefficient (0.96) in SIFT algorithm to detect deficiency in coffee plant [8]. To differentiate complex background, deep sparse extreme learning machines is used. Multiple methods are used to determine nutrient deficiency as it shows better performance for nutrient recognition [9]. In the era of digital agriculture, digital images and machine learning is used combine to solve the problems [5]. Nutrients play a very vital role in producing good crops. Plant deficiency affection is seen generally on the leaves [7]. Neural network makes it easy to detect nutrient deficiency by predicting accurately [6]. In this paper, we study about those various methods which can detect the deficiency of nutrients in crops using machine learning. These methods will help to improve the productivity and make better cultivation of crops. These methods will reduce the problems of labor and farmers and can live a better life than before. Machine learning includes image processing as well.*

***Keywords***- *machine learning, crops, detection, fertilizers, deficiency, nutrient, agriculture.*

## I. INTRODUCTION

India has 12th position in GDP ranking in agriculture globally and 7.68% of land under cultivation [7].Infection of crop had a great impact on both humans and animals [1]. It reduces the cultivation and quality of crops. Disease identification and diagnosis is very important to test whether the crop better quality or not. Some has used image processing technique to identify plant diseases as it is hard to detect them with naked eyes [1]. Utilization of Inception-ResNet v2 is used to predict, train and recognize nutrient through capture images. For tomato plant, Calcium and Potassium is used for development [6]. In order to save the crop from disease, early stage detection is very much important. In today's world of developing, technologies play a very important role in each and every sector of innovation. Nitrogen is very important for the plants to grow as it has important function in photosynthesis process. Due to development in computer vision, crops are tested using image-based analysis. We can even separately determine nitrogen content in crops using images mostly depend on Agriculture [10]. Farmers are facing multiple problems in cultivation of crops. They are unable to understand the problem in crops [2]. They are using traditional methods to identify the problems taking more time and giving less result. Early detection is very much important for the crops to monitor the insects using chemical pesticides. The early detection and identification of disease is not possible for the farmers and may cause serious disease to the crops. In this case, farmers use chemical pesticides to kill the insects or disease to save their crops [4]. The deficiency is identified in laboratory which mostly goes wrong due to changing environment. Nutrients deficiency means very acid or alkaline conditions; dryness and water logging can all make it difficult for plants to take up soil nutrient which causes some symptoms to plants. The nutrients deficiencies may appear in their leaves, stem, flowers, fruits and many other parts. Machine learning made it possible to study the nutrient deficiency using any part of plants/crops [3]. It is very important to have thirteen nutrients for efficient growth of plants i.e. Nitrogen, Phosphorous, Potassium, Magnesium, Sulphur, Molybdenum, Zinc, Boron, Copper, Calcium, Iron, Chloride, Manganese. They acquire these nutrients from the soil. If there is deficiency of nutrients, this affects the growth and quality of the plants/crops. These nutrients are divided into two types as micro-nutrients and macro-nutrients. The micro-nutrients are the elements which are essential for plants growth only in very small quantities which include Molybdenum, Zinc, Boron, Chloride, Copper, Manganese and Iron and macro-nutrients include Nitrogen, Phosphorous, Potassium, Sulphur, Calcium, and Magnesium[2]. These nutrients will help the farmers to have good and healthy cultivation of crops. But if there is deficiency of these nutrients then it may lead to stunted growth, browning and death of the crops.

 

There are various symptoms which identify the deficiency of nutrients in plants/crops shown in the figure as follows.


*Figure 1. Symptoms observed in crops/plants*


*Figure 2. Nutrients present in plants*

### 1.1 Nutrient Deficiency

The main causes of nutrient deficiencies include a poor diet that lacks essential nutrients, a disease or medication that impairs absorption, or both[4]. The body can store some nutrients, so that a deficiency may not be caught until the body has been without the nutrient for some time. The deficiency of nutrients affects the crops and may damage it before its growth.
The following table shows the effect of nutrient deficiency in plants [3].

***Table 1. Deficiency of nutrients and its effects on plants***

| Nutrients | Deficiency | Function | Toxicity |
|---|---|---|---|
| Nitrogen | Light green leaf and older leaves turning yellow that eventually turn brown and die. Growth is slow and mature early. | • Important in growth and development of vital plant tissue and cells.<br>• Hold genetic code in plant nutrients.<br>• Gives green colour | • Dark green leaves and Foliage.<br>• Leaf tips turn down.<br>• Yellowing on affected leaves. |
| Phosphorus | Growth is slow and stunted with older leaves as purple coloration particularly underside. | • Responsible for regulation of protein synthesis.<br>• Increase stalk and stem strength, flower formation and production.<br>Stimulate root development. | • Very rare and usually buffered by pH limitations.<br>Excess P can interfere with availability of Cu and Zn. |
| Potassium | Older leaves edge look burned, a symptom known as scorch. Easily lodge and sensitive to disease infestation. Poor quality of fruit and seed production. | • Control opening and closing of stomata.<br>• Activates enzymes<br>• Facilitates protein and starch synthesis. | • Cause yellowing of leaves lead to shedding and defoliation of leaves.<br>• Stunted growth lead to slow growth or poor developed roots and stems. |
| Calcium | Growing tips of roots and leaves turn brown and die. Edges look ragged and fruit quality affects with occurrence of blossom-end rot on fruits. | • Stimulate ammonium absorption.<br>• Guard cell physiology especially in stomata closure. | • Blossom end root.<br>• Yellow brown spots surrounded by sharp brown outline edge. |
| Magnesium | Older leaves turn yellow, growth is slow and some plants may easily infested by diseases. | • Chlorophyll formation.<br>• Synthesis of amino acids.<br>• Resistance to unfavourable factors. | • Yellowing between leaf veins.<br>• Early leaf fall. |
| Sulphur | Entire light green colour of plant along with older leaves turn yellow | • Formation of chlorophyll.<br>• Production of proteins.<br>• Activation of enzymes. | • Yellow leaves including veins.<br>• Leaf tips may yellow and |

 

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| | | | curl downwards. |
| Boron | Abnormal development of growing points becomes stunted and dying. Bad quality of fruits and grains are produced. | • It moves with plant tissue accumulate in the leaves. | • Chlorotic leaf tips.<br>• Leaf necrosis.<br>• Leaf falling.<br>• Even plant death. |
| Chlorine | Younger leaves are chlorotic and plants easily wilt. Plant disease infest when chlorine is deficient for wheat. | • Disease resistance and tolerance.<br>• Opening and closing of stomata.<br>• Plant growth and development. | • Starts as premature yellow in of leaves then in marginal or tip necrosis of older leaves. |
| Copper | Growth is slow, distortion of young leaves and death of growing point. | • Activates some enzymes in plants.<br>• Serves flavour and colour in vegetables and flowers. | • Excess Cu restricts root growth.<br>• Reduce branching and plants may die. |
| Iron | Interveinal chlorosis occurs on young leaves with eventual bleaching of new growth. Entire plant may be light green in colour. | • Essential for chlorophyll formation.<br>• Component of cytochromes.<br>• Essential for N fixation.<br>• Assist in nitrate and sulphate reduction. | • Occurs due to low growing medium pH or from and excessive application of Iron. |
| Manganese | Generally plant remains green in colour. When severe, plants will be stunted. | • Required for chlorophyll synthesis.<br>• Activate enzymes systems.<br>• Resistant to root pathogens. | • Occur when pH is below 5.5<br>• Form patches on older leaves.<br>• Burning of tips and margin of older leaves as reddish brown. |
| Molybdenum | Older and medium leaves become chlorotic first, leaf margins are rolled, growth and flower formation is restricted. | • Convert nitrate to nitrite then to ammonia before synthesize amino acids.<br>• Need to symbiotic N fixing bacteria in legumes to fix atmospheric nitrogen. | • Rolled margin.<br>• Growth reduction. |
| Zinc | Upper leaves shows interveinal chlorosis with eventual whitening of affected leaves. Leaves may be small and distorted with rosette form. | • Help to produce chlorophyll.<br>• A constituent of certain enzymes. | • Occurs at low pH value.<br>• Growth reduction, leaf chlorosis. |

### 1.2 Mobility of nutrients

**Nitrogen:**

1. It is mobility nutrient.
2. Deficiency appears on older leaves first.

**Phosphorous:**

1. Highly mobile nutrients.
2. Deficiency symptoms will appear in older leaves.

**Potassium:**

1. Leaf tip and marginal necrosis.

**Zinc:**

1. It is immobile in nature.

 

### 1.3 Methods

In order to detect the plants/crops for better cultivation, various methods has used by the scientists in the laboratories. Many technologies are used to gather information necessary for automation as Fourier transform electrical impedance spectroscopy etc [5]. It is very necessary to detect the crop at early stage so to reduce the deficiency of nutrients present in the plants [2]. This helps the farmers to add those nutrients and produce better quality of crops in less time.

The methods are as follows:

1) Image Processing
2) Image Segmentation
3) Convolutional Neural Networks
4) Post processing-Image enhancement
5) Matching techniques.

Image processing needs features such as edge, corners, ridges, blobs of plants. Edges and corners are mostly used in image processing to differentiate image from other one. The features from previous images are used to train the system to identify various nutrient deficiencies. The result of extraction is known as feature descriptor [4]. The learning of feature is divided into two types as Supervised and Unsupervised. Supervised is learning of features from labeled data which enable system to compute error degree to fail and use them as feedback to correct learning process such as neural networks. The Unsupervised is learning features from unlabeled data to identify low dimensional structures underlying high dimensional structures such as K-means clustering [11]. The above methods have some results about determine the threshold values for nutrients in crops.

The threshold values are as follows:

***Table 2. Nutrient deficiency along with its Threshold values***

| Sr. No. | Nutrient Deficiency | Threshold Values |
|---|---|---|
| 1 | Healthy plant | 175 |
| 2 | Manganese | 207 |
| 3 | Nitrogen | 200 |
| 4 | Potassium | 140 |
| 5 | Sulphur | 160 |
| 6 | Zinc | 115 |

The above thresholds values are used to determine what maximum amount of nutrients are required for the crops. The nutrient deficiency in plants can be improved by adding well-rotted manure or compost, and spreading organic mulches or leaf mould around existing plants. Digging it into soil to a depth of 50 mm can help to keep any nutritional problems at bay [11].

## II. Literature Review

Deficiency plays a very vital role in crops/plants to have good cultivation and save crops from getting damage [12]. In order to observe nutrient deficiency in plants, various methods were used by multiple publishers in their respective papers. In this literature review we will discuss about various methods were discussed. The summary of review papers is shown in the following table as follows:

***Table 3. Literature review of papers.***

| Sr. No. | Authors | Title | Summary |
|---|---|---|---|
| **1.** | Amirtha T, Gokulalakshmi T, Umamaheswari P, T Rajasekar | Machine Learning Based Nutrient Deficiency Detection in Crops | The captured image will be compared with the available dataset and it will tell which type of nutrient deficiency is present in the crop/plants. |
| **2.** | S. Jeyalakshmi, R. Radha | A Review on Diagnosis of Nutrient Deficiency symptoms in plant leaf image using Digital Image Processing. | The nutrient deficiency can be identified using various parts of plants such as leaf area, colour of leaf, veins area etc. |
| **3.** | Rahul Rathod, S Jayanth Balaji, Samarth S, Soumya A | Detection and Classification of Tomato Plant Leaf Diseases Using Convolutional Neural Network | The type of diseases using tomato leaf using convolution layer of Neural Networks. This will test the deficiency using neurons and its layers. |
| **4.** | Pavit Noinongyao, Chaiwat | Identification of Plant Nutrient Deficiencies | Identify nutrient deficiency using image analysis method using convolution neural network on |

 

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| | Wattanapaiboonsuk, Puriwat Khantiviriya, Sutsawat Duangsrisa | Using Convolutional Neural Networks | black gram. They discuss five types of nutrient deficiencies as Ca, Fe, K, Mg and N deficiencies, and a group of healthy plants. |
| **5.** | Amrutha A, Lekha R, Sreedevi A | Automatic Soil Nutrient Detection and Fertilizer Dispensary System | To restore levels of nitrogen, phosphorous, potassium in soil by measuring nutrients in it. |
| **6.** | S. A. Miller, F. D. Beed, C. L. Harmon | Plant Disease Diagnostic Capabilities and Networks | Improves speed and accuracy of disease diagnostics and pathogen detection. |
| **7.** | Komal Bodake, Rutuja Ghate, Himanshi Doshi, Priyanka Jadhav, Balasaheb Tarle | Soil Based Fertilizer Recommendation System Using the Internet of Things | Develop soil based fertilizer to make understand the farmers properly about the fertilizer. |
| **8.** | Indumathi.R, Saagari.N, Thejuswini.V, Swarnareka.R | Leaf Disease Detection and Fertilizer Suggestion. | Identification of disease by affected part of leaf using Image processing (K-means). |

## III. Future Scope

We know that, plant healthiness can be caused due to living organisms like insects, fungi etc. or non-living organisms like nutrient imbalance, soil moistures etc. Various methods were studied in this paper in literature review. In this paper, we study different types of methods which identify deficiency of nutrients in plants using machine learning [4]. The future scope includes rather than taking samples of plants, sensors will be used to test the nutrient deficiency. The sensor will tell the type of nutrient deficiency present and what type of fertilizer we need to use to reduce that deficiency [12]. The sensor will test the soil moisture, humidity, temperature as well as pHs. Weed remover can also be attached to improve agriculture process. The sensor will tell which type of nutrient is deficient in plant and how we can overcome that deficiency to keep plant healthy. It will cost more for the farmers but will be beneficial and profitable to buy with more facilities. They don't need to test it in the laboratory and will be tested easily through that sensor along with the results and overcoming solution [12]. It will also test the nutrient deficiency separately so to provide proper amount of nutrients to the crops.

## IV. Conclusion

Nutrients are very important for the plants for their growth. But, when there is deficiency of nutrients, it may lead to damage and or leaves may get burned. The identification of nutrients was not possible earlier in less time [4]. Machine learning has made it possible to identify deficiency of nutrients in less time using multiple methods including image processing, neural networks etc. The study of literature review discuss in this paper summarize the methods available to identify the deficiency of nutrients present in the plants. We can conclude that multiple methods are used to study nutrient deficiency in plants/crops [12]. As it is said prevention is better than cure, so we need to take preventive measures in order to produce good crops [7]. Machine learning technique is used which also includes image processing and it can be done in convenient and efficient manner to get the best result. For better production, nutrient detection is very important [10].

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