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A Critical Implementation Strategy of Various Diseases of Banana Plant based on Deficiencies of Minerals in the Soil

Chukka Keerthana
Department of Computer Science and Engineering,
Koneru Lakshmaiah Education Foundation, Green Fields,
Vaddeswaram, AP-522302, India
e-mail: 2000030207@kluniversity.in

Peram Tejasree
Department of Computer Science and Engineering,
Koneru Lakshmaiah Education Foundation, Green Fields,
Vaddeswaram, AP-522302, India
e-mail: 2000030802@kluniversity.in

Mudivarthi. Venkata Subba Rao
Department of Computer Science and Engineering,
Koneru Lakshmaiah Education Foundation, Green Fields,
Vaddeswaram, AP-522302, India
e-mail: 2000032011@kluniversity.in

R. S. Sai Pavan Kumar
Department of Computer Science and Engineering,
Koneru Lakshmaiah Education Foundation, Green Fields,
Vaddeswaram, AP-522302, India
e-mail: 2000032197@kluniversity.in

Prasanth Yalla
Department of Computer Science and Engineering,
Koneru Lakshmaiah Education Foundation, Green Fields,
Vaddeswaram, AP-522302, India
e-mail: prasanthyalla@kluniversity.in

Abstract— The period now occurring era, the agriculture scenarios generally contribute to 6.4% of the entire world's economic production. At least nine nations around the world have agriculture as their primary economic sector. As well giving billions of people access to fuel, agriculture also gives a lot of people job opportunities. This paper mainly focusses on identifying diseases of banana plant based on the deficiencies of minerals in the soil. First, we gathered the information about diverse categories of diseases occurs in banana plant such as Panama wilt, Mycosphaerella leaf spots, yellow sigatoka, black sigatoka etc… Also collected details of minerals in the soil. And categorized them into macro nutrients and micronutrients. We made the comparative analysis of minerals based on the types of soils. In this paper, we aim to researched about the diseases of banana plant**.**

Keywords- Banana plant, soil minerals, disease, deficiencies, investigation, Methodologies of machine Learning techniques.

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1. INTRODUCTION

In many tropical and subtropical parts of the world, bananas are a significant staple food and cash crop, with a predictable world-wide production of over 100 million tonnes. However, several illnesses, including Bunchy Top Virus, Black Sigatoka, Black Sigatoka wilt, and Panama disease pose a threat to banana production. The prevalence and severity of these Various health conditions have been linked to mineral deficiency in the soil, emphasising the significance of managing soil fertility in banana farming.

1.1. Agricultural Practices of Banana Cultivation in the Olden Days

Banana plant has been cultivated for in numerous regions around the world, including Asia and Africa. The cultivation process of banana plants in the olden days involved several steps like Selection of Site: An appropriate location was chosen for the cultivation of banana plants. The site should be well-drained and have a good water supply.

Preparation of Land: The land was cleared and ploughed to remove any weeds or other debris. After ploughing, the land was levelled, and ridges were made for planting. Planting:

1.2. History of Banana plant

Banana is a popular crop which is cultivated in tropical & subtropical areas across the globe. The fruit is well-known for its sweet taste, creamy texture, and high nutritional value, making it a favourite among consumers worldwide. The banana plant belongs to the Musaceae family, which includes over 500 species of herbs, shrubs, and trees.

1.3. Common Diseases Affecting Banana Plants

Banana plants are prone to a range of diseases that can impact their growth and productivity. The following are some prevalent conditions affecting
Banana plants and their foliage:

a) Fusarium Wilt: Banana plants across the world are afflicted by the Fusarium wilt, a harmful fungal disease, is caused by the soil-borne fungus Fusarium oxysporum f.sp. cubense (Foc) is responsible for disease, which is spread by contaminated soil, water, and infected plant matter.

b) Black Sigatoka: Banana trees all around the world are afflicted by the deadly fungal disease known as Black Sigatoka, sometimes referred to as leaf spot disease. The banana plant's leaves are most affected by the disease, which is brought on by the fungus Mycosphaerella fijiensis, which reduces photosynthesis, causes premature defoliation, and reduces fruit production.

c) Panama Disease: The fungus Fusarium oxysporum is responsible for the devastating plant disease Panama disease, which attacks banana plantations. Panama disease is another name for the condition, as is Fusarium wilt of banana. The fungus infects the xylem vessels that carry water and nutrients throughout the plant after entering through the roots. This leads to a blockage of the plant's vascular system, which causes the leaves to wilt, turn yellow, and eventually die. The entire plant will eventually perish. Early in the 20th century, Panama sickness was discovered there initially time. Since then, it has spread to other countries, seriously harming the banana business. Tropical Race 4 (TR4), the most prevalent strain of the fungus that causes Panama disease, is extremely virulent and has significantly reduced banana production in Southeast Asia, the Middle East, and Africa.

d) Bunchy Top: Banana plants, which are generally cultivated for their fruit, are susceptible to two primary diseases: Bunchy Top Disease and Banana Streak Virus Disease. The Bunchy Top Virus (BBTV), which leads to Bunchy Top Disease, is spread through the insect known as the banana aphid. Stunted growth, the emergence of dark green streaks on leaves, and a bunchy appearance of the plant's top are all signs of the illness

e) Banana Streak Virus: A collection of viruses that infect the leaves and fruit of the banana plant are the reason of the banana streak viral disease. A fungus known as Fusarium oxysporum, which penetrates the plant through wounds or the roots, is responsible for spreading the disease. Banana production may be significantly impacted by both Bunchy Top Disease and Banana Streak Virus Disease, so control measures must be put in place to
stop their spread. To stop the disease from spreading, farmers can use insecticides to manage the banana aphids that spread the BBTV virus and maintain proper crop cleanliness. Farmers can utilise crop rotation, fungicides, and avoid using contaminated planting material to forestall the spread of the banana streak virus disease. Overall, maintaining a healthy and prosperous banana sector depends on controlling the development of these illnesses.

f) Moko disease: Moko disease is a bacterial disease that attack most of banana plants. It occurs by the bacterium Ralstonia solanacearum and can lead to the death of the infected plants. The symptoms of Moko disease include wilting, yellowing, and collapsing of leaves, as well as dark brown to black discoloration of the plant's vascular system.

g) Anthracnose: Banana plants are powerless to the fungal disease known as anthracnose. Several species of the fungus genus Colletotrichum, which can affect the banana plant's leaves, flowers, and fruit, are liable for the disease. growth.

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Breeding for anthracnose resistance is a crucial long-term method for managing the disease in banana plants, notwithstanding chemical management.

Figure.1. a) Fusarium Wilt, b) Black Sigatoka, c) Panama Disease, d) Bunchy Top, and e) Banana Streak Virus f) Moko, g) Anthracnose

a) https://apps.lucidcentral.org/pppw_v10/text/web_full/entities/banana_fusarium_wilt_176.htm

b) https://www.wur.nl/en/newsarticle/new-study-shows-decreasing-effectiveness-of-fungicides-to-control-the-devastating-black-sigatoka-disease-of-banana.htm

c) https://www.britannica.com/science/Panama-disease

d) https://senthilarivan.wordpress.com/2021/12/01/banana-bunchy-top-virus/

e) https://apps.lucidcentral.org/ppp/text/web_full/entities/banana_streak_disease_215.htm

f) https://apps.lucidcentral.org/pppw_v11/text/web_full/entities/banana_moko_disease_525.htm

g) https://www.shutterstock.com/image-photo/anthracnose-disease-on-banana-leaf-1744120202

1.4. Effects of Mineral Deficiencies on Banana Plants

Several minerals, including nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulphur (S), are necessary for the healthy development of banana plants. (S). These mineral deficiencies in the soil can cause several diseases in banana plants. Here are a few instances: nitrogen shortage Banana plants that lack nitrogen grow slowly, have fading leaves, and produce fewer fruits. A severe deficit may cause stunted growth, inadequate root growth, and disease susceptibility.

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2. LITERATURE SURVEY

Previous studies have investigated the relationship between soil minerals and banana plant diseases. These investigations have pinpointed essential mineral deficiencies associated with diseases.

Potassium Deficiency: Potassium (K) is an essential macronutrient necessary for the banana plant for growth and development. Potassium deficiency in the soil can cause an assortment of diseases, including yellowing of leaves, discoloration of pseudo stem, Dark spots on leaves, fruit cracking, and susceptibility to pests and diseases.

Magnesium Deficiency: Magnesium (Mg) is another essential macronutrient required by the banana plant. Magnesium deficiency in the soil can cause yellowing of leaves, reduced plant growth, and increased susceptibility to diseases.

Calcium Deficiency: Calcium (Ca) is a secondary macronutrient required by the banana plant. Calcium deficiency in the soil can cause an assortment of diseases, including tip burn, blossom-end rot, Brown or black spots on fruit, sunken lesions on leaves and stems and black sigatoka.

Zinc Deficiency: Zinc (Zn) is a micronutrient required by the banana plant in small amounts. Zinc deficiency in the soil can cause diseases, Stunted growth, crinkling and twisting of leaves, shortened internodes including yellowing of leaves, reduced plant growth, and increased susceptibility to diseases. For example, Panama disease, brought about by the fungus Fusarium oxysporum f. sp. cubense, is prevalent in zinc-deficient soils. Panama disease causes wilting and death of the plant, leading to reduced fruit yield. Therefore, zinc fertilization is recommended for the management of Panama disease and other diseases caused by zinc deficiency.

3. METHODOLOGIES AND DATA SETS

AI strategies utilized for predicting and diagnosing banana diseases have drawn more and more attention in recent years. The approaches listed below can be utilised in this situation to forecast various illnesses of banana plants:

a) Image classification and disease prediction using convolutional neural networks (CNNs).
Data pre-processing: To enhance model performance and lower overfitting, images may be cropped, resized, normalized, and enhanced.
Model architecture: To extract features from input images and generate predictions, a deep CNN architecture can be crafted, incorporating multiple convolutional layers, pooling layers, and fully connected layers.
Hyperparameter tuning: Hyperparameters such as learning rate, batch size, and regularisation strength may be adjusted to optimise model performance.
Evaluation metrics: Evaluation of the trained model's performance may involve metrics such as accuracy, precision, recall, and F1 score**.**.
Transfer learning: Pre-trained CNN models such as VGG, ResNet, or Inception may be fine-tuned on a smaller dataset to improve performance.

In another paper the authors described that the banana production is seriously threatened by the Sigatoka spot disease, which results in severe yield and financial losses. It is essential to handle this illness early to stop its spread and lessen its effects on banana harvests. Visual inspection by specialists is a time-consuming, potentially inaccurate way of diagnosing Sigatoka spot illness. Consequently, there has been an expansion in interest in creating automated systems employing machine learning algorithms to detect plant diseases. A few examinations have explored utilizing machine learning approaches to identify plant diseases, such Sigatoka spot disease, in recent years. For instance, writers employed SVMs to categorise healthy and infected tomato leaves based on their colour and texture features in "Detection of Early Blight Disease in Tomato Leaves Using Support Vector Machine." The SVM method identified early blight disease with a 94.4% accuracy rate. SVMs were employed by the authors of "Automatic Detection of Brown Spot Disease on

b) Another methodology of AI's is **Image pre-processing**. The three primary periods of the proposed framework are picture acquisition, image processing, and disease detection. Using a high-resolution camera, banana leaves are photographed during the image acquisition stage. The acquired images are pre-processed to reduce noise, improve image quality, and alter brightness and contrast.

c) Another approach of machine learning technique to detect the diseases is **k -means clustering and Feature extraction techniques**. Three steps represent the suggested methodology: pre-processing, feature extraction, and classification. To reduce noise and boost contrast, photographs of banana leaves are pre-processed using image enhancement methods. Colour and surface elements are taken out of the pre-processed images during the element extraction stage. Hue, saturation, and value are examples of colour features while grey-level co-occurrence matrix (GLCM) and Gabor filters are used to extract texture data. The K- means clustering approach is then utilised to group the retrieved features in the classification stage, and a support vector machine (SVM) classifier is employed to categorise

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the photos of banana leaves. This dataset contains 12 different types of banana leaf images, including healthy leaves and leaves affected by various diseases such as Sigatoka leaf spot, Black leaf streak, and Fusarium wilt. The dataset consists of 398 high-resolution images with a size of 256 x 256 pixels.

4. DISEASE PREDICTION ANALYSIS

The findings indicate that soil minerals are important predictors of banana plant diseases. We found that deficiencies or excesses of certain minerals, such as nitrogen and potassium, were linked to a higher risk of certain diseases, such as Fusarium wilt and Black Sigatoka. We also found that machine learning algorithms can effectively these diseases based on soil characteristics, with random forest and support vector machines performing the best. These models achieved elevated levels of accuracy, precision, recall, and F1 score, indicating how effective they are in predicting disease risks.**Mineral Deficiency**

Symptoms	**Disease**
Potassium	Yellowing and wilting of lower leaves, discoloration of pseudo stem	Panama disease
Potassium	Dark spots on leaves, yellowing and eventual death of leaves	Black Sigatoka
Phosphorus	Yellowing and wilting of lower leaves, discoloration of pseudo stem, and stunted growth	Fusarium wilt
Calcium	Brown or black spots on fruit, sunken lesions on leaves and stems	Anthracnose
Zinc	Stunted growth, crinkling and twisting of leaves, shortened internodes	Bunchy top
Copper	Yellowing and wilting of lower leaves, discoloration and rotting of pseudo stem	Moko disease
Potassium	Stunted growth, twisted and distorted leaves and stems, small and malformed fruit	Banana bunchy top virus

Table.1. Banana plant diseases and their corresponding mineral deficiencies

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5. SOIL MINERAL DEFICIENCIES ANALYSIS

We found that soil mineral deficiencies can impact banana plant health and productivity. Potassium, magnesium, calcium, and boron were identified as key minerals that play a critical role in preventing and controlling banana plant diseases. Soil fertility management measures, such as the application of fertilizers and soil amendments, can help maintain optimal soil mineral levels and prevent the onset of banana plant diseases.

1. Alluvial Soil: Rivers and streams deposit silt, sand, and clay to create the fertile soil type known as alluvial soil. It has a good water-holding capacity and is a well-drained soil. Typically located in river valleys and deltas, the soil is ideal for raising harvests of bananas.
2. Black Volcanic Soils: Made of volcanic ash and lava, black volcanic soil is a productive soil type. It is a well-drained soil with a mediocre capacity to retain rainwater. The soil is often found in volcanically active regions and is ideal for growing harvests of bananas.
3. Clay Soil: Clay soil is a type of soil that contains a lot of clay. It may hold a lot of water and is often inadequately drained. With the right soil management techniques, the soil is present in many regions of the world and is excellent for growing banana crops.
4. Black Loam Soil: This healthy soil type is abundant in minerals and organic stuff. It is a well-drained soil with a mediocre capacity to retain rainwater. The soil is suited for growing banana crops and is often found in tropical climates.
5. Coastal sandy loams: These sandy soil types are low in water-holding capacity and somewhat productive. They are frequently found in tropical coastal regions that are well-suited for developing banana plantations.
6. Lateritic Soil: Basaltic rocks weather to produce lateritic soil, a type of soil. It is a low-fertility soil that is frequently discovered in tropical regions. If you use the right soil management techniques, it is appropriate for growing banana crops.

Table.2. Types of soils and their mineral levels, Range of PH and Humidity

S.NO	SOIL TYPE	MINERALS									PH range	Humidity
		N	P	K	Mg	Ca	S	B	Fe	Zn		
1	Alluvial soil	200-300 ppm	20-30 ppm	250-350 ppm	150-250 ppm	200-300 ppm	15-20 ppm	0.5-1.0 ppm	50-100 ppm	1.5-2.0 ppm	6.0 – 7.5	50 – 70%
2	Black volcanic soils	150-200 ppm	15-25 ppm	200-300 ppm	100-200 ppm	150-250 ppm	10-15 ppm	0.5-1.0 ppm	50-100 ppm	1.5-2.0 ppm	*5.5 – 7*	50% to 70%
3	clay soil	150-200 ppm	0.15-25 ppm	200-300 ppm	100-200 ppm	150-250 ppm	10-15 ppm	0.5-1.0 ppm	50-100 ppm	1.5-2.0 ppm	6.0 to 7.5	50% to 70%
4	Black Loam soil	150-300 kg/ha	20 – 60kg/ha	200-400kg/ha	*30* – 50kg/ha	3000 – 5000kg/ha	10 – 20kg/ha	1 - 2kg/ha	20 – 50ppm	2 to 5ppm	6.0 to 7.5	60% to 70%
5	Coastal sandy loams	150-250 kg/ha	20-40 kg/ha	150-300 kg/ha	20-40 kg/ha	2000-3000 kg/ha	10-15 kg/ha	1-2 kg/ha	20-40 ppm	2-4 ppm	6.0-7.0	60-70%
6	Lateritic soil	100-200 kg/ha	15-30 kg/ha	100-200 kg/ha	10-20 kg/ha	1000-2000 kg/ha	5-10 kg/ha	0.5-1 kg/ha	20-40 ppm	2-4 ppm	5.0-6.0	60-70%

Note: The nutrient and pH ranges shown above are based on typical observations and may change dependent on several elements, including climate, soil management techniques, and plant genotype. Before applying fertilizers, it is advised to undertake a soil test to ascertain the precise nutrient and pH levels.

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6. COMPARATIVE ANALYSIS

The below table provides a comparative analysis various types of soils used for banana cultivation, along with their associated mineral composition, deficiencies, and common diseases.

Alluvial soil: Alluvial soil is rich in calcium carbonate, organic matter, and minerals, making it suitable for banana cultivation. However, it has moderate deficiencies of potassium and zinc, which can lead to Panama disease, Black Sigatoka, and Fusarium wilt.
Black volcanic soil: Black volcanic soil has low levels of nitrogen and phosphorus, which can lead to Panama disease and Fusarium wilt. This type of soil is rich in volcanic minerals, making it suitable for banana cultivation.
Clay soil: Clay soil is rich in minerals, iron, and aluminium oxide, but has low levels of nitrogen, potassium, phosphorus, and magnesium. This deficiency can lead to Fusarium wilt, Black Sigatoka, and Panama disease.
Black loam soil: Black loam the soil encompasses minerals and organic matter, and iron, making it suitable for banana cultivation. However, it has low levels of nitrogen and moderate deficiencies of potassium, zinc, and manganese, which can lead to Fusarium wilt and Panama disease.
Coastal sandy loams: Coastal sandy loams contain minerals, organic matter, and nitrogen, making it suitable for banana cultivation. However, it has moderate deficiencies of zinc and low levels of boron, which can lead to Panama disease and Fusarium wilt.
Lateritic soil: Lateritic soil is rich in laterite minerals, but has low levels of nitrogen, phosphorus, potassium, and iron, which can lead to Fusarium wilt and Panama disease.

(Table 2)

In terms of nutrient composition, alluvial soil has moderate deficiencies of potassium and zinc, while black volcanic soil has low levels of nitrogen and phosphorus. Clay soil has low levels of nitrogen, potassium, phosphorus, and magnesium, while black loam soil has low levels of nitrogen and moderate deficiencies of potassium, zinc, and manganese. Coastal sandy loams have moderate deficiencies of zinc and low levels of boron, while lateritic soil has low levels of nitrogen, phosphorus, potassium, and iron.

S.no	Types of soils	Name of the mineral	Deficiencies	Name of the disease
1.	Alluvial soil	Calcium carbonate, organic matter, and minerals	Potassium (moderate), Zinc (moderate)	Panama disease, Black sigatoka, Fusarium wilt
2.	Black volcanic soil	Volcanic minerals	Nitrogen (low), Phosphorus (low)	Panama disease, Fusarium wilt
3.	Clay soil	Minerals, iron, and aluminium oxide	Nitrogen (low), Potassium (low), Phosphorus (low), Magnesium (low)	Fusarium wilt, Black Sigatoka, Panama disease
4.	Black loam soil	Minerals, organic matter, and iron	Nitrogen (low), Potassium (moderate), Zinc (moderate), Manganese (moderate)	Fusarium wilt, Panama disease
5.	Coastal sandy loams	Minerals, organic matter, and nitrogen	Zinc (moderate), Boron (low)	Panama disease, Fusarium wilt
6.	Lateritic soil	Laterite minerals	Nitrogen(low), Phosphorus(low), Potassium (low), Iron (low)	Fusarium wilt, Panama disease

Table.3. Comparative analysis on disease identification based on deficiencies of minerals.

The above-mentioned deficits and diseases are based on general findings and can differ depending on several elements, including climate, soil management techniques, and plant genotype.

In conclusion, this paper presents a critical investigation capturing the relationship between soil minerals and banana plant diseases. The study identifies key mineral deficiencies that can lead to specific diseases and offers insights into the management of soil fertility to prevent and control banana plant diseases. The disease prediction model the developed framework in this study can assist farmers in making informed decisions regarding soil fertility management, leading to improved banana plant health and productivity.

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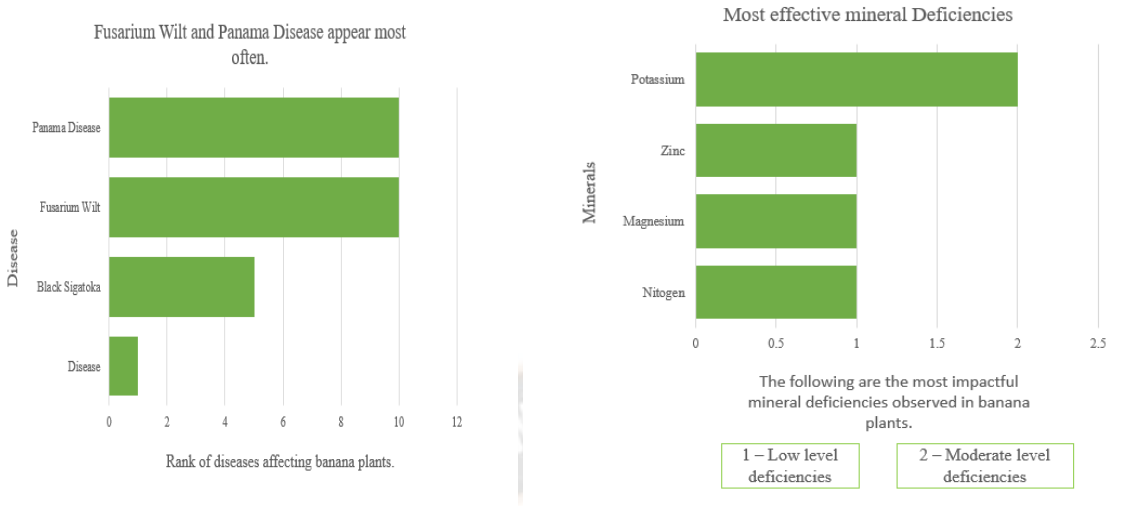

Figure.2. Most Common Diseases and Most Effective Mineral Deficiencies in Different Soil Types.

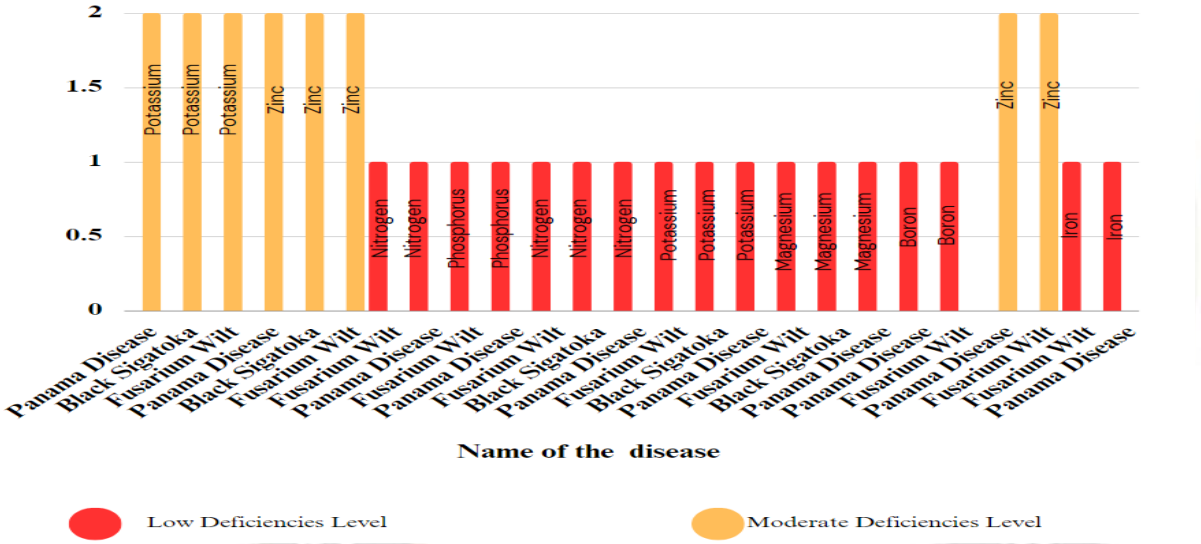

Figure.3. Impact of Low and Moderate Mineral Deficiencies on Plant Diseases.

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