Comparative Study on Rice Plant Nutrient Deficiency Detection

(To be submitted in partial fulfillment of the requirements for the course on programming in software metrics)

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Abstract: This paper compares different approaches to detect rice plant nutrient deficiency using various deep learning algorithms. Various techniques have been implemented involving image pre–processing, data generation, and augmenting the dataset to train the model, test the model and compare them efficiently using various visualization techniques. These techniques have been implemented assuring the major factors are capacity, robustness, security, and visual quality. The proposed methods have been compared against statistical parameters like accuracy, f1 – score, precision, recall, and support. The experimental results suggest that using a particular method is subjective to its application. The following packages and libraries are included in the project's dependencies: NumPy, pandas, seaborn, matplotlib, Tensorflow, Keras, sklearn, and opencv. This project has been implemented on the google collab platform using the CPU runtime.

Key Words: Image Classification, Plant Nutrient Deficiency, Deficiency Detection, Rice Plant Nutrient Deficiency, Hydroponics.

1 Introduction

In recent years, soilless farming techniques like hydroponics have gained popularity. It has a number of benefits over conventional farming techniques, including a higher yield, better plant quality, and less water use. The Nutrient Film Technique (NFT), one of the most popular hydroponic methods, involves continuously passing a shallow stream of nutrient-rich water through a plant's root system to supply the nutrients needed for growth and development.

While short-term crops like lettuce, tomatoes, strawberries, and raspberries have been grown successfully using NFT, it's potential for growing staple crops like rice is still largely untapped. Because rice plants have different nutritional needs from other crops, cultivating rice hydroponically with the NFT approach has certain special difficulties.

Potential nutritional deficits are one of the main issues with hydroponically cultivating rice with NFT. Hydroponic systems rely on nutrient solutions that must be carefully balanced to ensure the plant receives the right amount of each nutrient, in contrast to traditional soil farming, where nutrients are delivered into the soil gradually over time. Nutritional shortages in the plants may come from an improperly balanced nutrient solution, which may affect growth and productivity.

Researchers are doing experiments to look into the nutrient uptake and growth patterns of rice plants under NFT settings to solve these potential nutritional inadequacies. Researchers can spot regions where the nutrient solution may be deficient and work out the best ways to augment it by analyzing the nutrient uptake and growth patterns of the rice plants.

For instance, iron is one of the crucial elements required for the development and growth of rice plants. However, hydroponic systems are equally susceptible to deficiencies, particularly in alkaline circumstances. In order to solve an iron shortage in rice cultivated hydroponically using NFT, researchers have proposed several methods, such as adding chelated iron to the nutrient solution, reducing the pH of the nutrient solution, or utilizing iron-rich fertilizers.

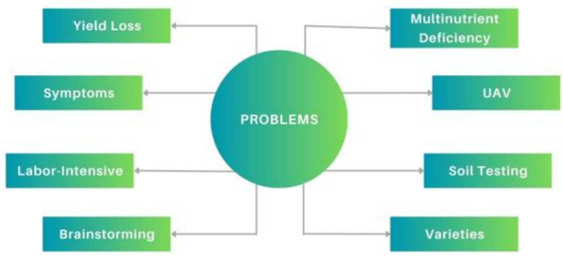


Fig-1: Problem for rice plant nutrition deficiency detection

Let's sum up by saying that the Nutrient Film Method (NFT) is a well-liked hydroponic technology that is effective for growing transient crops. But its potential for generating food staples like rice is still largely untapped. One of the major issues with hydroponically using NFT cultivating rice is nutritional inadequacies. To guarantee that rice plants produced with NFT receive the right amount of each nutrient for optimal growth and development, researchers are undertaking tests to determine the most efficient ways to replenish the nutrient solution. These studies' findings may have a big impact on sustainable agriculture in the future and on hydroponics' ability to help solve the world's food security problems.

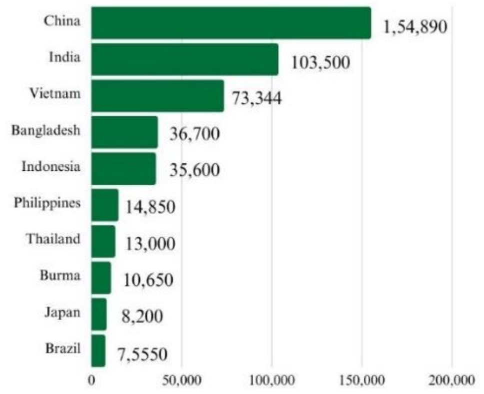


Fig-2: Country-wise (top ten) consumption of rice

One of the most widely consumed staple foods worldwide is rice, with the top 10 rice-consuming nations being China, India, Indonesia, Bangladesh, Vietnam, Philippines, Burma, Japan, Brazil, and Nigeria. China consumes more than 143 million metric tons of rice yearly and produces most of it. With an average annual consumption of 38.8 million metric tons, Indonesia ranks third among rice consumers. Bangladesh consumes an average of 34.1 million metric tons of rice per year, making it the fourth-largest consumer in the world. With an average annual consumption of 22.7 million metric tons, Vietnam ranks fifth among rice consumers. With an average yearly consumption of 8.4 million metric tons, Brazil ranks tenth among rice consumers. Tenth-largest rice consumer in Nigeria.

2 Methodology Approaches In Hydroponics

2.1 Existing Practices

Since the dawn of civilization, agriculture has been a vital sector. The production of goods including grain, livestock, dairy, fiber, and fuel-related raw materials has made a substantial impact on the global economy. These agricultural products are used as raw materials by many industries, including the building, textile, and food and beverage industries. Agriculture's relevance to commerce and society can be linked to its role in the world economy and supply chain.

In the diets of humans, fruits and vegetables are essential sources of vitamins, minerals, and other nutrients. They offer vital nutrients that are necessary for sustaining a balanced diet, including as fiber, proteins, and carbs. Several minerals, including magnesium, zinc, and phosphorus, which are essential for the body's healthy operation are also included in fruits and vegetables. Also, they are a good source of vitamins A, C, and E, which support healthy skin, hair, and eyes as well as the immune system. Fruits and vegetables are also known to improve human palates with their distinctive flavors while offering health advantages.

Rapid testing and plant analysis are two methods for identifying nutritional deficits in plants. Quick testing involves examining the soil or plant tissues to quickly determine the nutrient levels. On the other hand, a more thorough method called plant analysis involves examining different plant components like leaves, stems, and roots in order to precisely pinpoint nutrient deficits. These methods are essential for guaranteeing ideal plant development and growth.

In modern agriculture, hydroponic systems are becoming more common. Instead of using soil to grow plants, these systems use a fertilizer solution based on water. In areas with problems like variable weather patterns, intense heat, and limited space, hydroponic farming is becoming more and more popular. Modern hydroponic systems frequently have automated parts that depend on environmental variables like humidity and temperature to control the plant's environment. These elements make sure that the plants have the best possible conditions for growth to yield high-quality crops.

2.2 Challenges of the Traditional Approach

The ability of plants to germinate, grow, fend off disease and pests, and reproduce depends on a range of nutrients. Plant growth and development can be dramatically impacted by nutrient excesses or deficits. A plant cannot finish its life cycle if it lacks a crucial nutrient. Similarly, too much of a nutrient can cause damage or even result in plant death. In order to achieve ideal plant growth and development, it is necessary to maintain the right nutrient levels in the hydroponic system.

For areas with problems like irregular weather patterns, intense heat, and limited space, hydroponics may be the answer. The necessity for ongoing nutrient solution monitoring, the danger of illnesses spreading swiftly through the water-based system, and the expensive initial setup expenses are some of the particular difficulties that hydroponics presents. To make sure that hydroponics is a practical choice for sustainable agriculture in the future, these issues must be resolved.

2.3 TYPES OF HYDROPONICS

Name	Description
• *Wick*	Although an absorbent "wick" draws nutrient-rich water up from a water reservoir to the root system zone, plant roots develop downward through the medium. The roots may access air (oxygen) thanks to the growth media.
• *Air-Gap*	The upper portion of a plant's root system is exposed to air while the roots are partially submerged in water that is rich in nutrients (oxygen).
• *Raft*	The roots of the plants are suspended in nutrient-rich water while they are situated on a floating surface. An aquarium-style pump adds oxygen to the water, which the roots absorb.
• *Ebb and Flow*	Roots of plants spread through a surface. Water that contains nutrients is frequently pumped to the root zone region (e.g., every 30 minutes) and then allowed to drain back into a water reservoir.
• *Top Feeder*	Roots of plants spread through a surface. The roots may access air (oxygen) thanks to the growth media. A water reservoir is filled with nutrient-rich water that is pumped to the surface of the medium, allowed to percolate down to the root zone, and then drained.
• *Nutrient Film Technique (NFT)*	Plants are arranged on a floating platform suspended in a trough with a small incline. The root system of the plant hangs with the upper portion exposed to the air (oxygen). Water that is rich in nutrients is pumped into the trough from the top (higher) end, exposing the bottom portion of the roots to it. In order to return to a water reservoir, the water must pass through (down) the other root systems.
• *Aeroponics*	Plant roots are placed in an enclosed area that is open to air (oxygen), and that is often (every 30 minutes, for example) irrigated with nutrient-rich water or misted with it.

Table 1: Types of Hydroponics [1]

2.4 CLASSIFICATION OF CROPS GROWN WITH HYDROPONICS

Various crops could be grown with hydroponics but it works well with these crops under various conditions

Greens	Vegetables	Fruits	Aromatic plants
• Green beans • Cauli-flower • Celery • Broccoli • Lettuce • Pea • Leek • Spinach	• Tomato • Carrot • Beetroot • Cucumber • Auber-gine • Onion • Pepper • Radish • Courgette	• Cantaloupe • Strawberry • Raspberry • Blueberry • Grape • Lemon • Apple using dwarf trees	• Basil, • Cori-ander • Mint • Thyme • Sage • Tarra-gon • Rose-mary

Table 2: Classification of crops grown with hydroponics[9].

There are many benefits to adopting hydroponics for growing, some of which are listed below:

- Usability and spatial effectiveness. Food may be grown anywhere a regulated atmosphere can be used thanks to hydroponics.
- Depending on the type of plant, vertical configurations can be created to increase yield output.
- Assurance of quantity and quality - Crop rotation is required in traditional agriculture to maintain soil fertility; however, hydroponic crops can be repeated as often as necessary, boosting the yield per cycle per crop. Also, since nutrition is given in accordance with the physiological needs of the plant, produce quality is guaranteed.
- Sustainability. Water evaporation, seepage, and pollution are minimized, and rinse water is not required because the product is not in contact with the soil, and the nourishing solution is recycled. Furthermore, a regulated environment ensures the best circumstances for growth and protection against pests and diseases that affect plants, obviating the need for chemicals and pesticides and conserving vital natural resources like soil and water.
- Economics. Operations in hydroponics are sometimes less complicated than those needed in conventional agriculture. In this regard, traditional methods call for labor-intensive preparations prior to planting, including the expense of large machinery and specialized equipment, which finally may be rented.

Serial No.	Types of deficiency	Symptoms
1	*Nitrogen (N)*	All leaves occasionally have a bright green chlorotic tip that is present on aged leaves. Excessive stress causes leaves to die. The leaves are narrow, short, erect, and lemon yellow in colour, with the exception of juvenile leaves, which are greener in colour.
2	*Potassium(K)*	The tips of older leaves are where dark green plants with yellowish-brown leaf edges or dark brown necrotic patches initially appear. When there is a severe K deficit, leaf tips turn yellowish brown.
3	*Phosphorus (P)*	The leaves are "dirty" dark green in colour and thin, short, and quite upright. Although young leaves might seem healthy, they eventually turn brown and die.

Table 3: Types of nutrient and their following symptoms[40].

2.5 LITERATURE SURVEY

A study on hydroponic crop cultivation (HCC) for food security in small island developing states was presented by Cassidy et al. (2020). The importance of HCC for the long-term development of small island developing states was discussed by the writers. The study emphasized the significance of HCC in reducing the risks associated with food security, water shortage, and climate change. The authors explored the opportunities and difficulties involved in implementing a conceptual model for HCC [1].

An ARIMA (Autoregressive Integrated Moving Average) model-based TDS (Total Dissolved Solids) prediction system for hydroponic vertical farms was put forth by Kaur et al. (2022). The authors presented a prediction model based on the ARIMA method and talked about the importance of TDS prediction in hydroponic farming. According to the study, the suggested model can forecast TDS levels in hydroponic vertical farms with high accuracy, enabling farmers to optimize fertilizer supply and boost crop yields [2].

In the temperate region of India, Bhat et al. (2022) studied the water and fertilizer requirements for the soilless cultivation of tomato plants under protected conditions. The authors evaluated the water and nutritional needs of tomato plants in controlled environments and discussed the significance of soilless cultivation in tomato farming. According to the study, tomato plants should have a fertilizer solution content of 2.5 dS/m and a water requirement of 3.5 L/day/plant [3].

The classification of various nutritional shortages in tomato plants was the subject of a study by Sai et al. (2022) using sample space reduction and electrophysiological signal decomposition. The authors talked about the need for nutrient deficiency detection in tomato cultivation and developed a system for categorizing nutrient deficiencies based on sample space reduction and electrophysiological signal decomposition. According to the study, the suggested method may detect nutrient deficits in tomato plants effectively. This can assist farmers in streamlining fertilizer supply and increasing crop yields [4].

Tan et al study from 2021 used both traditional machine learning and deep learning techniques to identify tomato leaf diseases based on leaf photos. The authors examined the effectiveness of traditional machine learning and deep learning approaches for disease classification and talked about the importance of early disease detection in tomato cultivation. The study demonstrated that deep learning techniques performed better than traditional machine learning techniques in classifying tomato leaf diseases, which can assist farmers in identifying and treating diseases at an early stage [5].

A deep learning-based image-based autonomous diagnostic system for tomato plants was proposed by Khatoon et al. in 2021. The authors talked about the value of automatic diagnostic systems in tomato farming and offered a deep learning-based technique for the automatic diagnosis of tomato plant illnesses. The research shows that the suggested method can identify tomato plant diseases with accuracy, assisting farmers in maximizing disease management and increasing crop production [6].

Using convolutional neural networks, Claudio et al. (2020) describes a vision-based analysis of tomato leaves for diagnosing nutrient deficits (CNNs). The scientists trained a CNN to categories tomato leaves depending on the type of nutritional shortage using a publicly available dataset of tomato leaves with various nutrient deficiencies. They were able to identify nutritional shortages in tomato plants with an accuracy of 90% on the test set, illustrating the promise of CNNs in this area [7].

A strategy for estimating low nutrient levels in tomato crops is suggested by Ponce et al. (2021) by utilizing machine learning to analyze leaf photos. In order to train a machine learning model to detect nutritional deficiencies from leaf images, the authors gathered a dataset of tomato leaves with various nutrient deficiencies. They established the potential of this method for non-invasive monitoring of nutrient shortages in tomato crops by achieving an accuracy of 80% on the test set [8].

A strategy for identifying nutritional shortages in rice crops using a weighted average ensemble learning approach is presented by Talukder et al. (2023). In order to predict the type of nutrient shortage, the authors gathered a collection of photos of rice plants with various nutritional deficiencies and trained a group of machine learning models. For the test set, they had a 91.5% accuracy rate, showing the method's potential for correctly identifying nutritional deficits in rice crops [9].

Overall, the studies examined in this literature review show the promise of machine learning and vision-based methods for identifying and tracking nutrient deficits in plants, especially in hydroponic and soilless growing systems. In order to provide food security in tiny island developing states and other areas with limited arable land, these technologies can offer non-invasive and automated means for monitoring crop health and enhancing agricultural productivity.

Author Name	**Key Findings**
Cassidy et al. (2020)	Hydroponic crop cultivation can provide a solution for food security in small island developing states.
Kaur et al. (2022)	An ARIMA model can be used to predict TDS levels in hydroponic vertical farms.
Bhat et al. (2022)	Nutrient management is critical for soilless cultivation of tomatoes in protected environments.
Sai et al. (2022)	Electrophysiological signal decomposition can be used to classify different nutrient deficiencies in tomato plants.
Tan et al. (2021)	Deep learning methods outperform classical machine learning methods for classifying tomato leaf diseases based on leaf images.
Khatoon et al. (2021)	A deep learning-based diagnostic system can accurately identify different types of nutrient deficiencies in tomato plants based on leaf images.
Claudio et al. (2020)	A CNN can be used to accurately classify nutrient deficiencies in tomato plants based on leaf images.
Ponce et al. (2021)	Machine learning can be used to estimate nutrient deficiencies in tomato crops based on leaf images with reasonable accuracy.
Talukder et al. (2023)	A weighted average ensemble learning approach can be used to accurately diagnose nutrient deficiencies in rice crops based on plant images.

Table 4: Key Findings in hydroponics from the mentioned authors [10].

2.6 Analysis on Rice Plant

Our ability to produce food is essential to our survival. For the nutrition of a large portion of the people in Asia, Latin

America, and Africa, rice is extremely important. Almost half of the world's population depends on it for food security. 95% of the world's rice is produced in developing nations, with China and India producing about half of it on their own. China and India are the two biggest users, each accounting for around 25% and 30% of global consumption, respectively. An increase in rice output will be necessary to address the food problem.

2.7 The Need for technological development in rice plant cultivation:

To fulfill the growing demand for rice, maximize the use of finite resources, alleviate the effects of climate change, reduce yield losses from pests and diseases, and enhance sustainability, rice plant farming must adopt new technologies.

Factor	Description
Increasing demand	The rising population is driving up the demand for rice. To address this demand, technology can assist improve rice output.
Limited resources	Since there is a shortage of land, water, and manpower for growing rice, technology can help make the most use of these resources while also increasing output and lowering prices.
Climate change	To lessen the effects of climate change, technology can be used to improve crop management techniques and create rice varieties that are more resilient to climate change.
Pests and diseases	In order to use less pesticides, technology can assist in creating pest-resistant crop types and enhancing crop management techniques.
Sustainability	By using fewer resources, having less of an impact on the environment, and enhancing social welfare, technology can contribute to greater sustainability.

Table-5: Factors influencing the yielding of rice plant [38].

2.8 Nutrients Required for the growth of rice plants:

Plant development and growth depend on nutrients. Conditions of nutrient toxicity and inadequacy impede normal plant growth and display recognizable symptoms. Plants require all the essential nutrients in the right proportions for optimum development, growth, and production. The management of rice's integrated nutrients offers various advantages for improving soil fertility and long-term crop productivity. N, P, and K are the three primary macronutrients; Mg, Ca, and S are the secondary macronutrients; and Zn, Fe, Mn, Cu, B, Mo, and Cl are the six micronutrients. The most crucial nutrients for plants are nitrogen (N), phosphorus (P), potassium (K), and Sulphur (S).

Nutrients	**Roles**
Nitrogen	• Nitrogen plays a crucial role in the formation of chlorophyll, the pigment that permits photosynthesis in plants. • It promotes rapid growth and the development of additional tillers in rice plants, both of which increase yields. • Throughout the rice growing cycle, nitrogen is routinely administered at various periods, with the early vegetative stage receiving the most attention. • Excessive nitrogen use might cause lodging, which is when rice stems bend and break as a result of rapid growth.
Phosphorus	• The rice plant needs phosphorus to transfer energy, especially during the reproductive stage when grains are produced. • It also promotes the growth of the plant's roots and increases its capacity to withstand stress. • Phosphorus is normally provided as a base dose at planting time, and top dressing can be added as needed throughout the later growth phases. • Phosphorus deficiency can result in stunted plant development and decreased grain production.
Potassium	• Potassium is essential for the rice plant's ability to absorb and transport water as well as for the maintenance of general plant health. • It also aids in controlling the stomatal openings of the plant, which govern how much water is lost through transpiration. • Throughout the rice growing cycle, potassium is routinely added in a number of doses, with the largest concentrations administered during the panicle initiation stage. • Potassium deficiency can result in a reduction in photosynthesis, a reduction in grain filling, and an increase in disease susceptibility.
Zinc	• The rice plant needs zinc, a micronutrient, for a number of physiological activities like protein synthesis and enzyme function. • It contributes significantly to the growth of seedlings and can enhance crop establishment in places with subpar soil. • Zinc is frequently given as a foliar spray or as a soil additive, especially in regions with naturally low zinc levels. • Growth stunting, delayed maturity, and decreased grain quality can result from zinc deficiency.

Table 6: Nutrients required for the rice plants and their respective roles [39]

Each nutrition deficiency has impact in different areas and its discussed below:

Nutrient	Impact of deficiency
Nitrogen	• stunted growth and produce fewer tillers, resulting in lower yields. • Plants may also appear pale green or yellow due to reduced chlorophyll production. • Late application of nitrogen can result in delayed maturity and reduced grain quality.

	• make plants more susceptible to pests and diseases.
phosphorus	• Plants may have purple or crimson staining, and leaves may appear dull or bluish-green in appearance. • A lack of phosphorus will cause the rice plant to mature later and make it more prone to rice disease. • Narrow, short, and extremely upright leaves are a sign of P insufficiency. • Rice's greater susceptibility to illness and delayed maturation
Potassium	• The leaf tips turn a yellow-brown colour. • Makes leaf margins and tips appear burned or charred. • A reduction in yield due to smaller and lighter rice grains. • In extreme situations, a potassium shortage might cause rice stems to lodge or shatter.
Zinc	• Lowers lowland productivity. • Decreases the operation of alcohol dehydrogenase. • It reduces rice seedlings' ability to endure anaerobic soil conditions and decreases anaerobic root metabolism. • Plants can also develop chlorosis, or leaf yellowing, especially in their younger leaves. • Plants lacking in zinc can be more prone to lodging and drought stress.

Table 7: Impact of nutrients on rice plant [40].

2.9 Advantages

Advantages of cultivating rice using hydroponics are discussed below:

Ref	Advantages
[1]	increased yield in comparison to conventional soil-based farming techniques.
[2]	precise nutrient delivery, which leads to better plant growth and development.
[3]	Water use efficiency has increased while usage has decreased.
[5]	fewer disease and pest issues as a result of controlled growing conditions.
[6]	increased planting location flexibility and decreased land use.
[7]	decreased labour needs as a result of some operations being automated.
[8]	decrease in the likelihood of flooding and drought.
[9]	greater crop consistency and decreased yield unpredictability.
[10]	Possibility of year-round manufacturing in regulated settings .
[4]	efficiency in the use of fertilisers and pesticides to reduce the negative effects on the environment.

Table 8: Advantages of cultivating rice using hydroponics[10].

2.10 Disadvantages

Disadvantages of cultivating rice using hydroponics are discussed below:

Ref	Disadvantages
[1]	Substantial infrastructure and equipment startup costs.
[2]	There may be a learning curve and some technical challenges associated with putting hydroponics technology into practise.
[3]	Dependence on a reliable source of electricity to transfer nutrients and water.
[4]	Disposal of used nutrient solutions may cause environmental problems.
[5]	Higher possibility of equipment or power failures causing system failures.
[6]	Important environmental factors in hydroponic systems, including as humidity and temperature, are difficult to control.
[7]	Hydroponic equipment and supplies come in a variety of pricey and limited varieties.
[8]	A small variety of rice varieties that are appropriate for hydroponic growing.
[9]	Reduced nitrogen uptake efficiency in rice plants grown hydroponically is a possibility.
[10]	Reliance on a reliable supply system for fertilizers and hydroponic supplies.

Table 9: Disadvantages of cultivating rice using hydroponics [32].

Hydroponics is a method of growing plants without soil, using nutrient-rich water instead. While hydroponics has many advantages over traditional soil-based methods, there are also some disadvantages that should be considered. Here are some disadvantages of hydroponics.

Ref	Drawback	description
[1]	High initial cost	The cost of supplies and equipment can make setting up a hydroponic system unaffordable for some farmers.
[2]	Requires expertise	Making mistakes with hydroponics may be expensive and requires a certain amount of knowledge and ability to set up and maintain.
[3]	Dependence on electricity	Operating hydroponic systems requires electricity, which might be a drawback in regions with erratic power sources.
[4]	Risk of disease	Because water is a necessity for hydroponic systems, there is a

		chance that illness and viruses will spread through the water supply, which can be challenging to manage.
[5]	Risk of nutrient imbalances	Precision nutrient balances are essential in hydroponic systems, because imbalances can affect the health of the plants.
[6]	Environmental impact of materials	The materials used in hydroponic systems, such as the disposal of plastic containers and synthetic fertiliser solutions, can have an effect on the environment.

Table 10: Drawback of cultivating rice using hydroponics [27].

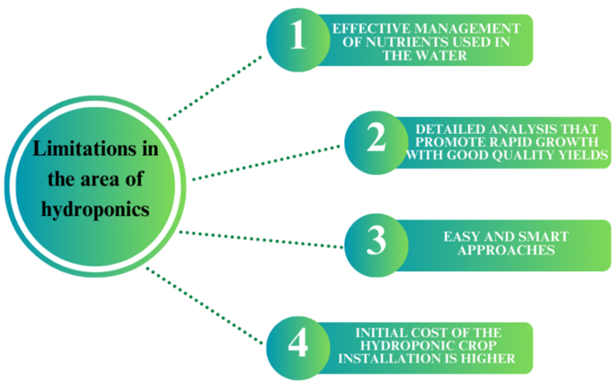


Fig-3: Major Limitations of Hydroponics

3 Proposed Idea

The development of a mobile application powered by AI that enables farmers to identify nutrient deficiencies in rice plants using deep learning models like AlexNet, VGG-16, Resnet34, EfficientNet-b0, MobileNet-v2, or Xception is one suggestion for rice plant nutrient deficiency detection. Using the camera on their mobile smartphone, farmers could use the application to snap pictures of their rice plants. The application would next examine the photos to see if the plants have nutrient shortages using the chosen deep learning model. The program might give farmers an intuitive user interface that shows the nutrients present in their rice plants and offers suggestions for addressing any shortfalls. This would make it easier for farmers to spot nutrient deficits early on, before they really harm their crops. A sizable dataset of rice plant photos that have been tagged to highlight the nutritional deficits present would be used to train deep learning models like AlexNet, VGG-16, Resnet34, EfficientNet-b0, MobileNet-v2, or Xception. Images of rice plants with various nutritional shortages, such as a lack of nitrogen, phosphorus, or potassium, would be included in the dataset. Once trained, the models can be incorporated into the mobile application to enable in-the-moment analysis of photographs collected by farmers. The programmer would be created to be user-friendly and available to farmers in rural locations with spotty internet access. Overall, the suggested solution might assist farmers in increasing crop yields and decreasing losses brought on by nutritional deficiencies in their rice plants. It might also be applied to other types of crops, enhancing food security in regions where crop failures brought on by nutrient deficits are frequent.

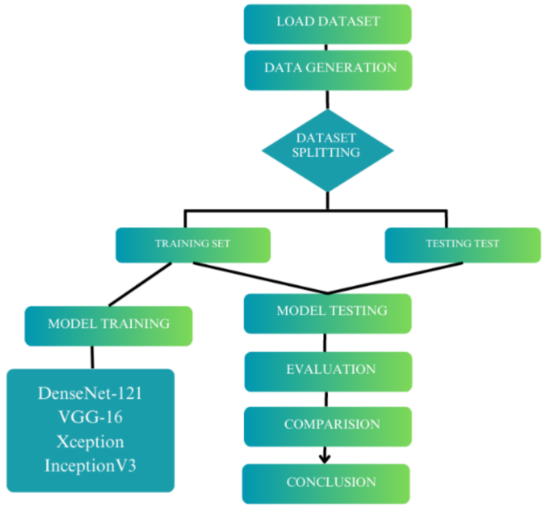


Fig-4: Flow Diagram for Rice Plant Nutrient Deficiency Detection

4 Architectural Diagram

A system is a smartphone software that analyses sample photos of leaves collected from rice plants in the field using the phone's built-in camera. Five leaf samples per hectare are adequate to represent the entire field, while the number of samples is dependent on the size of the rice field. The digitized dataset, which serves as the foundation for calculating the nitrogen content of the photographed rice plant leaf color, is what gives the program its intelligence. The program converts each image individually before averaging the samples and comparing the results. The outcome is shown, offering advice on how much fertilizer should be used, and the data is stored in the database for future use.

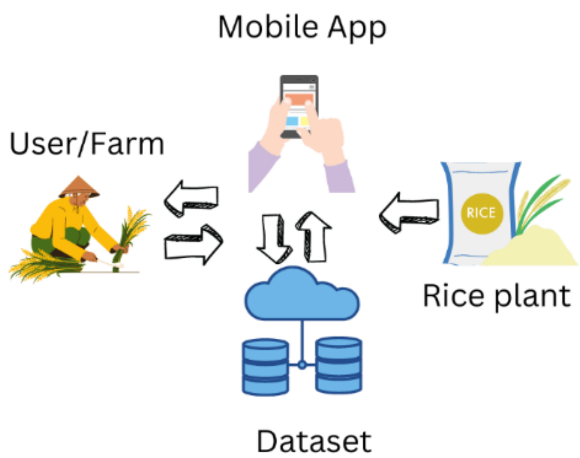
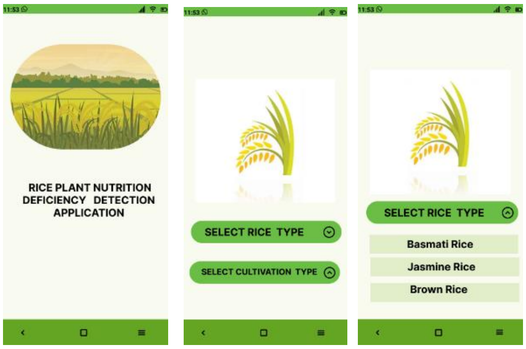
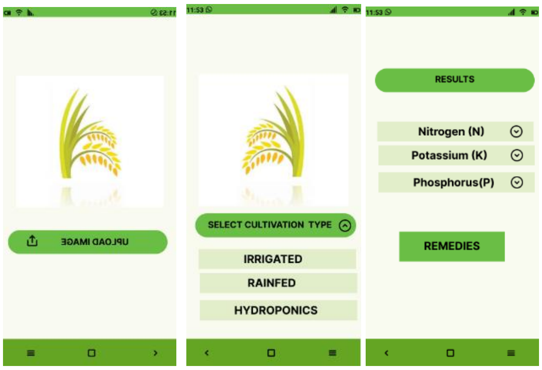


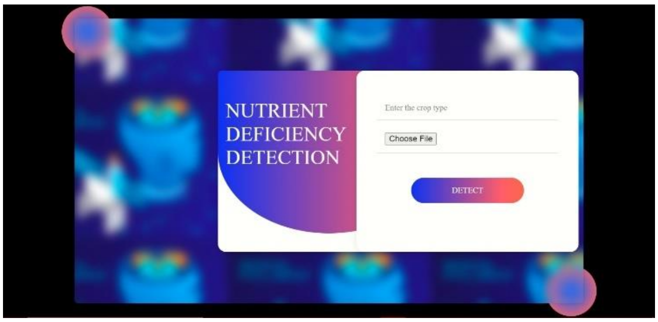
Fig-5: Architectural Diagram for *Rice Plant Nutrient Deficiency Detection* [18]

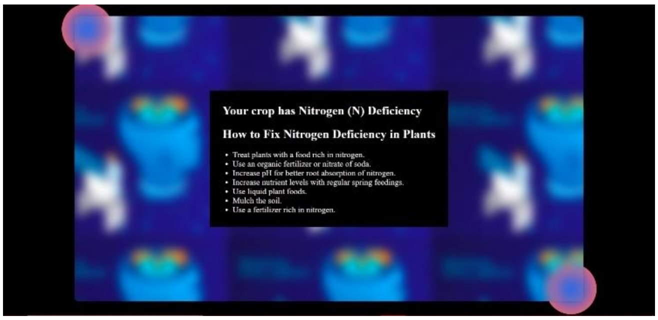
5 Implementations

5.1 Prototyping of the Application









5.2 Results

According to the comparative study, we can conclude that Xception deep learning model has the highest accuracy in classifying the nutrient deficiency of the rice plant accurately, we have determined the following macro average:

Model	Macro Average
Xception	93%
VGG16	92 %
DenseNet121	92 %
InceptionV3	88 %

Furthermore, the project also revealed the importance of hydroponics type of horticulture, highlighted the various importance and emphasized the need to adapt to hydroponics type of horticulture for better yield.

Overall, the results of this project provide valuable insights into the nutrient deficiency detection in rice plant and need for hydroponics type of horticulture and suggest potential avenues for future research or intervention.

6 Future Scope

Hydroponic systems are becoming more and more popular for growing rice because they provide a number of advantages over traditional soil-based methods, including improved control over plant nutrition, effective water management, and higher yields. One essential aspect of hydroponic rice farming is the capacity to track and spot nutrient shortages in plants in real-time. By improving their fertilizer management processes and preventing crop losses, growers can benefit from this capability.

Here are a few potential future developments for hydroponic systems used to identify nutrient deficits in rice plants:

- Sensor technology: new sensors for measuring plant nutrient levels in hydroponic systems have been developed that are extremely sensitive and precise. These sensors can be incorporated into the hydroponic system to give growers real-time information on the nutritional state of the plants and assist them in making educated decisions regarding fertilizer management.
- AI and machine learning: Machine learning algorithms can be trained to recognize patterns in sensor data and spot early indications of nutrient deficits in rice plants. This offers farmers the chance to implement the necessary improvements before the deficit worsens and has an impact on crop yield.
- Nutrient management software can be developed to analyze sensor data and provide recommendations for nutrient management depending on the specific needs of the rice plants. By lowering the danger of nutrient deficiencies, growers' nutrient management practices can be improved.
- Biotechnology: Novel rice varieties may be developed as a consequence of biotechnology breakthroughs that are better able to absorb nutrients from the hydroponic solution or that are more resilient to nutrient deficiencies. This may result in higher crop yields and a reduction in the frequency of fertilizer applications.

Overall, the topic of hydroponic rice plant nutrition deficiency detection offers many opportunities for technological advancements and innovation. By utilizing these advancements, growers may boost crop yields and contribute to a more efficient and sustainable agricultural system.

7 Conclusions

After reading the research articles, it is evident that hydroponics systems have become more popular for growing rice due to a number of benefits like improved plant nutrition, effective water utilization, and higher yields. To maximize nutrient management strategies and avoid crop losses, producers must be able to identify nutrient deficiencies. Several methods for identifying nutrient deficits in hydroponic rice growing have been covered in a number of studies. For instance, Chavan et al. (2021) proposed a sensor- and IoT-based hydroponics-based fertilizer management system for sustainable rice farming. Computer vision technology was utilized by Li et al. (2018) to identify nutrient deficits in hydroponic tomato plants. A nutritional analysis for tomato plants grown in hydroponic systems was also supplied by Yara (2021). Furthermore, the application of hydroponics for rice paddy nursery has been covered in some study publications. For instance, Rice Today (2021) reported a novel method for growing rice in India that uses hydroponics for the nursery of rice paddy fields. Some research studies have also looked at the production of rice variants that are more nutrient-deficit resistant. In order to maximize the supply of nutrients to rice plants, Sekar et al. (2020) created a smart nutrient delivery system.

We can draw the conclusion that rice cultivation in hydroponic systems has the potential to change the agricultural sector. Growers may enhance their nutrient management methods, lower crop losses, and boost crop yields by utilizing technological advances and advancements such as sensors, IoT devices, computer vision, and machine learning.

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