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Grapes Quality Prediction Using Iot & Machine Learning Based on Pre Harvesting

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Abstract----Minimizing pesticide use, preserving water, as well as enhancing soil health are just a few of the sustainable farming techniques that must be carefully considered while growing grapes of a high calibre. These practices can help preserve the environment and ensure the longevity of the vineyard. However, it is difficult for the farmers to find the suitability of the soil and its environment to cultivate grapes with high quality. Thus this research aims to evaluate the fitness of the soil for the fitness of growing quality grapes with the aid of machine learning algorithm. The research was done on Nasik region which is called as the "Grape Capital of India" situated in Maharashtra. Total of 154 villages were considered for the examination and soil specimens were collected and sent to the government testing lab in Maharashtra. The soil characteristics by considering both micro and macro nutrients, and the water characteristics were obtained from the lab. Also the climatic features, quality of the petiole and fruit characteristics were included for creating the dataset. These data was given to six different machine learning algorithm to classify the soil by defining whether the soil is fit for grapes or not. Moreover, this research proposed to analyze the correlation between the nutrients by which the relationship and dependency between the different nutrients and features were considered for defining the grapes quality. Also both the micro and macro nutrients were given equal importance in defining the soil quality suitable for obtaining high quality grapes. Based on the results obtained, Pimpalas Ramche contains more nutrients for the grape to grow more successfully based on samples gathered from different vine yards and the decision tree classifier scores better than any other classifiers among the machine learning algorithms employed in terms of accuracy.

Keywords-Nitrogen, Machine Learning, Vineyard, Random forest, Decision tree, Nave Bayes, Support Vector Machine.

I. Introduction

A major portion of the population is employed in agriculture, which is a key sector of the Indian economy and contributes substantially to the GDP of the nation. India is second in the globe for the production of agriculture, which includes grains, fruits, vegetables, and spices. Grape cultivation is an important horticultural activity in India, with the country being one of the world's largest producers of grapes [1]. The majority of grape cultivation in India is focused on table grapes, which are used for direct consumption, although some grapes are also used for wine production. Due to its importance to the Indian economy & addition to export revenue, grape farming is a significant sector of agriculture. The eighth-largest producer of grapes in the world is India, and the production of grapes provides a significant portion of the country's farmers with a living [2].

India is home to several grape-growing regions, primarily located in the southern and western parts of the country. Nashik, located in the western part of Maharashtra, has a mild climate and produces high-quality table grapes. Sangli, another major grape-growing region in Maharashtra, has a warm and dry climate and produces high-quality grapes. Bijapur, located in the northern part of Karnataka, is another region that is ideal for growing grapes due to its semi-arid climate [3]. Hyderabad, located in Telangana, is known for its high-quality grapes grown in the surrounding areas. In Tamil Nadu, the districts of Coimbatore, Krishnagiri, and Dharmapuri are known for their high-quality table grapes grown in a tropical climate. Overall, India's grape-growing regions have a suitable climate for grape cultivation and produce high-quality grapes that are exported worldwide [4].

Several factors can significantly influence the quality of grapes produced. The climate is one of the critical factors that can impact grape quality, with grapes preferring moderate temperatures for optimal growth and development. Soil quality is also essential, as the soil's nutrient content, drainage, and pH levels can impact grape growth and development [5]. The variety of grape used is another crucial factor, as different grape varieties have distinct flavour profiles and characteristics. Pests and diseases can also impact grape quality, with grapevines being susceptible to a range of pests and diseases [6]. Proper irrigation and water quality are crucial for grape growth and development, as is the use of sustainable and organic agricultural practices. Finally, proper harvesting and storage techniques are essential to maintain grape quality and prevent damage that could impact their flavour and texture [7].

Considering soil properties is crucial for grape cultivation as soil quality can significantly impact the growth, development, and quality of grapes. Grapes require nutrient-rich, pH-balanced soils that drain well and have good drainage. The ability of the

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soil to retain water, its texture, and its structure are all crucial factors in grape growing [8]. The accessibility of crucial minerals, like nitrogen, phosphorus, and potassium, that are required for grape growth and development, is influenced by soil characteristics. The availability of these nutrients can impact the grape's flavour, aroma, and overall quality. The soil's pH level can also impact the grape's acidity, which is an essential characteristic that contributes to the grape's flavour profile. Soil properties can also influence the grapevine's root growth and development, which can affect the vine's ability to absorb water and nutrients [9].

For grape cultivation, the essential nutrients required include nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur. These nutrients are crucial for growth then development of healthy grapevines and the production of high-quality grapes. Nitrogen is necessary for vegetative growth, phosphorus for root development and fruiting, and potassium for overall plant health and fruit quality [10]. Calcium is essential for the production of healthy cell walls, which can prevent diseases and pests, while magnesium and sulphur are necessary for photosynthesis and enzyme production. Therefore, maintaining adequate levels of these nutrients in the soil is crucial for optimal grapevine growth and development and the production of high-quality grapes [11].

Depending on several input parameters including soil texture, nutrient content, organic matter, pH, and other environmental conditions, machine learning can be utilised for forecasting soil quality. Regression algorithms, decision trees, SVM, and neural networks are a few examples of machine-learning methods which can be utilised for estimating soil quality [12]. Gathering and pre-processing knowledge gathered from many sources, including soil samples, weather information, and satellite imagery, is the initial stage in applying machine learning to estimate the quality of soil. The ML algorithm is then trained using this data. Following training, the algorithm may be utilised for predicting soil quality based on fresh input data. According to the soil quality and other environmental conditions, the framework, for instance, can be used to forecast agricultural production in a certain area [13].

There is a strong relationship between soil quality and grape quality. The flavour, aroma, and general quality of the grapes are all strongly affected by the soil in which they are grown. The composition of the soil can affect the growth and development of the grapevine, as well as the uptake of nutrients and water [14].

Some of the factors that can affect soil quality and grape quality include:

1. Soil pH: In soil with a pH around 5.5 and 7.0, grapes thrive. The ability of the grapevine to absorb nutrients can be impacted by soil that is either too acidic or too alkaline.
2. Soil texture: The proportions that are equal of sand, silt, and clay in the soil are referred to as its texture. Grapes grow best in well-drained soil with a balanced texture, which allows for proper root development and water uptake.
3. Nutrient content: Grapes require a range of nutrients to grow and develop properly, including nitrogen, phosphorus, and potassium. Soil that is deficient in these nutrients can result in poor grape quality.
4. Water availability: Grapes require adequate water to grow and develop properly. Soil that is too dry or too wet can affect grape quality.

In this research work the soil sample is gathered from nearly 154 vineyard & these collected samples are first tested in government soil testing Lab in Maharashtra, and the dataset has been collected from the lap which is been utilized in ML systems & forecast the soil nutrients.

II. LITERATURE SURVEY

Zheng Zhao et al [15] in this study, the nutritional characteristics of the soil were studied in 73 typical vines in the Shanghai suburbs. The findings demonstrated that the 73 selected vineyards had very different soil nutrient properties, with planting area and planting age being the main determinants. Only in the various planting zones were there noticeable pH changes in the soil. The majority of soil nutrients were at a high or extra-high level, indicating that less fertiliser should currently be used and more organic fertiliser should be. Utilising fertilisation in the best possible way based on the nutrients in the soil is essential for preserving resources for production, increasing revenues, and improving the surrounding environment.

Safwan Mohammed et al [16] The objective of this research is to determine how soil micronutrients (Cu, Fe, Mn, Zn, and B) are distributed regionally & whether they may be utilised for cultivating grapes in Syria's Jabal Al Arab. Random soil samples were taken from grape farms around the study region in order to meet the study's goals. To ascertain the content of soil micronutrients, soil analysis were then carried out. With 1.1, 12.06, 11.2, 2.6, 0.3 ppm for Cu, Fe, Mn, Zn, and B, correspondingly, the results showed that soil micronutrient concentrations did not meet the minimal level for grape development. Additionally, the research region was found to have significant deficiencies in Cu, Fe, Mn, Zn, and B in 63%, 39%, 34%, 76%, and 74% of the study area, respectively.

R. Vijaya kumar et al [17] the study of surface soil samples from 18 villages in Tamilnadu, Sirkali taluk in India revealed that the accessible levels of the macronutrients N, P, and K were 85% low, 15% medium, & 100% low for N, P, and K, accordingly. Fe, Mn, Cu, and Zn, which are all readily accessible micronutrients, were found to be insufficient in 26% of cases and sufficient in 74%. Mn showed positive correlation with pH, EC, and OM while following the identical pattern as Fe with OC, EC, and OM while exhibiting a negative link with

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pH. Cu showed a positive relationship with OC and OM but a negative association with both, in contrast to pH, EC, and Zn.

K. Archana et al [18] Machine learning is a crucial field of informatics with applications in the agriculture industry. To select the best suitable crops, the suggested strategy focuses on macronutrients (NPK), pH, electrical conductivity in the soil, and temperature. A voting-based ensemble classifier system that incorporates an agricultural dataset suggests the suitable crops. Increasing productivity in farming through crop yield estimation and forecasting as well as improving soil fertility through regular crop rotation. The accuracy of this approach was 92%.

Asad Ali et al [19] Diseases in crops, like grape leaves, are frequently brought on by a lack of natural nutrients. High production and high quality can be achieved by creating a computerised framework that helps classify the harmed grape leaf into one of four categories: K-deficient, P-deficient, N-deficient, or Mg-deficient. To do this, a dataset of grape leaves suffering from nutritional deficiencies was built and supplemented. For K-, Mg-, P-, and N-deficient grape leaves, the average individual accuracies were 77.97%, 77.74%, 81.81%, and 78.09%, correspondingly, after pre-processing and the usage of Convolution Neural Network (CNN) classifier. The outcomes, which were also compared with the results of later studies, showed that the method we proposed scored superior than the earlier examinations. When used on mobile devices for real-time results, our experimental findings are equally practical and advantageous.

Miguel Ángel Olego et al [20] The primary goal of this investigation was to ascertain the effects of excessive dolomitic lime treatment on grapevines growing in acidic soil. The three-year (2014–2016) installation of Vitis vinifera L. cv. Menca in a vineyard was followed by an analysis of its impact on topsoil fertility parameters (0–30 cm), petiole and berry nutrient levels, berry weight, and required quality features. Through the use of a mixed approach with random effects (year of sampling) and both fixed variables (liming treatments), data analysis revealed that excessive liming decreased the manganese levels in both leaf and berry tissues. The over liming effect on vine nutritional status and harvest quality features was poorly understood prior to the completion of this study.

III. Research Methodology:

In this study, the quality of grapes is detected by analyzing soil nutrients, water characteristics, climatic characteristics, nature of petiole and grapes quality for determining insufficiency of nutrients required to grow high quality grapes by promoting grape plant growth and yield by the grapes plant.

A. Research Area:

This study was conducted in Nasik, Maharashtra. Nashik, the Indian state of Maharashtra, is known as the "Grape Capital of India." Nashik is a prominent grape-producing region in India, and its vineyards produce a sizable amount of the country's grape output. Nashik's climate and soil conditions are suitable for grape growing, and the region is home to a number of wineries and vineyards. Thompson Seedless, Sonaka, Manik Chaman, and Sharad Seedless are some of the famous grape varietals planted in Nashik.

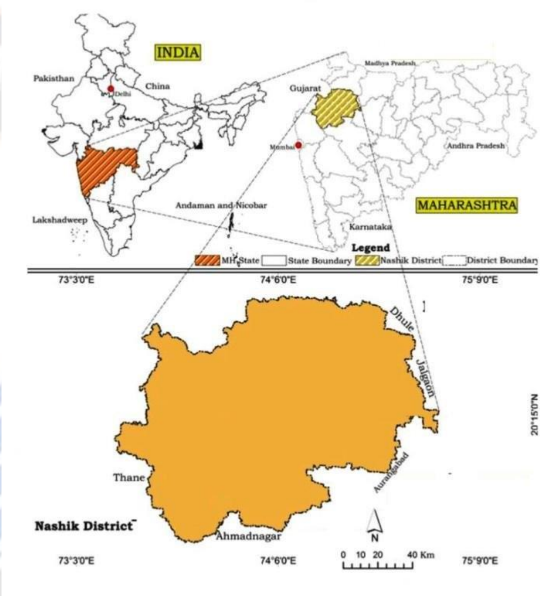

Figure 1. Geometry of Nashik District Maharashtra

Nashik's terrain is ideal for grape growing. The region offers a varied geography, with hills, plateaus, and valleys providing varying altitudes and soil types suited for cultivating a range of wine varieties. The climate is also favourable for grape growth, with warm and dry days during the grape growing season assisting in achieving high sugar levels and maturity in the grapes.

The Godavari River, which runs through Nashik, is extremely important in grape growing. The river aids in irrigation and provides frost protection throughout the winter season. Nashik's grape-growing zones are generally located at elevations ranging from 500 to 800 metres (1,640 to 2,625 feet) above sea level. The soil types in these places are predominantly red and black, well-drained, and fertile. Nashik's hills and plateaus also provide the ideal slope for grape farming, allowing for excellent water drainage and sunlight exposure for the grapevines. The geometry of the Nashik has been shown in Figure.1.

B. Research Parameters:

Grape cultivation requires specific soil and climatic conditions for optimal growth and nutrient uptake. Here are some of the key factors that impact grape cultivation:

1. Soil quality: Grapes do best in soils that drain well and have a pH between 5.5 and 7.0. The soil must be rich in organic matter, with good fertility, and a good balance of nutrients. Grapes are sensitive to saline soils, so the soil should have low levels of salt. For optimal development, grapes need a variety of nutrients, such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. The soil should have adequate levels of these nutrients, and fertilizers may need to be applied to maintain optimal levels.
2. Climatic conditions: Grapes grow best in regions with warm summers and cool winters. The ideal temperature range for grape cultivation is between 15°C to 25°C during the growing season. Grapes require adequate sunlight for photosynthesis, and moderate rainfall during the growing season. Excessively wet conditions can lead to fungal diseases, while drought can affect grape quality and yield.
3. Water quality: The quality of the water used for irrigation can also impact grape cultivation. Water with high levels of salts or minerals can affect grape growth and fruit quality. It is crucial to keep an eye on the irrigation water's quality and make any necessary corrections.
4. Pest and disease control in petiole: Grapes are susceptible to a range of pests and diseases, including fungal infections, insects, and viruses. To sustain crop health and yield, it's critical to deploy efficient pest and disease control strategies.

1) Soil Quality:

a) Macro Nutrient:

Numerous macronutrients found in soil are crucial for the maintenance and development of plants. The three primary macro nutrients required by plants are:

1. Nitrogen (N): The vital part of amino acids, which constitute the fundamental blocks of proteins, is nitrogen. Additionally, it is necessary for the creation of nucleic acids, that serve as the foundation for DNA and RNA. Nitrogen is taken up by plants in the form of nitrate or ammonium ions, and is used to synthesize proteins, nucleic acids, and other important molecules.
2. Phosphorus (P): The creation of ATP, the main kind of energy utilised by cells, requires phosphorus. It is also important for the formation of DNA and cell membranes. Phosphorus is taken up by plants in the form of phosphate ions, and is used to produce ATP, nucleic acids, and other important molecules.
3. Potassium (K): Many different plant activities, including the control of water balance and the activation of enzymes, need potassium. It is also important for the transport of sugars and other molecules within the plant. Potassium is taken up by plants in the form of potassium ions, and is used to regulate water balance, activate enzymes, and transport molecules within the plant.

In addition to these three primary macro nutrients, plants also require other macro nutrients in smaller amounts, such as calcium (Ca), magnesium (Mg), and sulphur (S). These macro nutrients play important roles in plant growth and development, such as providing structural support, regulating pH balance, and facilitating metabolic processes.

b) Micro Nutrient:

A variety of micronutrients found in soil are crucial for the formation and maturation of plants. These micronutrients are often present in small amounts, but are still important for the health and productivity of plants. Some examples of micronutrients found in soil include:

1. Iron (Fe): For plants, iron is a crucial micronutrient since it is required for the synthesis of chlorophyll, which is important for photosynthesis. Iron also plays a role in respiration and nitrogen fixation.
2. Manganese (Mn): Manganese is involved in a number of plant processes, such as the production of chlorophyll and the metabolism of carbohydrates and nitrogen. Manganese is also important for the plant's defense against stress and disease.
3. Zinc (Zn): Zinc is involved in the production of auxins, which are hormones that regulate plant growth and development. Zinc is also important for DNA synthesis, and contributes to the production of chlorophyll.
4. Copper (Cu): Copper is involved in the production of lignin, which provides structural support to the plant. Copper is also important for the metabolism of carbohydrates and nitrogen, and is involved in the production of chlorophyll.
5. Boron (B): Boron is important for cell wall formation and membrane function, as well as for the metabolism of carbohydrates and other nutrients. Boron also plays a role in pollen tube growth and fruit development.

These are only a handful of the numerous micronutrients that are present in soil and are crucial for the creation and maturation of crops.

2) Water Quality:

Grapevines are sensitive to the quality of the water they receive; thus the water's purity is a crucial consideration while growing grapes. Poor water quality can negatively affect the growth, yield, and quality of grapes, and can also lead to disease and pest problems.

The ideal water quality for grape plant cultivation includes the following parameters:

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1. pH: For ideal grape growth, the pH of the water ought to be around 6.0 and 6.5. pH values outside this range can affect nutrient uptake by the plants and cause growth problems.
2. Chlorine: The water should be free of chlorine or have a low concentration of chlorine. Chlorine can damage grape plants and affect their growth.
3. Calcium and Magnesium: The water should contain sufficient levels of calcium and magnesium, which are important for grape growth and development.
4. Iron: The water should be free of high levels of iron, which can affect grape plant growth and cause leaf discoloration.

In addition to these parameters, it is important to ensure that the water used for grape plant cultivation is free of pathogens, such as bacteria and viruses that can cause diseases in the plants. Testing the water quality regularly and making adjustments as needed can help ensure optimal growth and yield for grape plants.

3) Climate Condition:

Grape cultivation requires specific climatic conditions to grow and produce high-quality fruit. Generally, grapes grow best in temperate to warm climates with abundant sunshine and moderate rainfall. Here are some specific climate conditions that are ideal for grape cultivation:

1. Temperature: Warm weather is necessary for grapes to thrive through their growing period. A temperature ranges of 15-30°C (59-86°F) during the day and 10–15°C (50–59°F) at night is suitable for grape growing.
2. Sunlight: Grapes need plenty of sunlight to ripen properly. The ideal location for grape cultivation is a spot that receives at least 6 hours of sunlight a day.
3. Rainfall: Grapevines require moderate rainfall, with a total of 500-700 mm (20-28 inches) per year being optimal. Too much rainfall can cause disease and reduce fruit quality, while too little rainfall can lead to water stress and reduced yields.
4. Humidity: Grapes grow best in areas with low to moderate humidity levels. A great deal of humidity might make it more likely for fungal diseases to spread, that can reduce fruit quality and yield.
5. Soil: Deep, well-drained soils with plenty of organic matter are preferred for grapes. Soil with a pH between 5.5 - 7.0 is ideal for grape cultivation.

4) Quality of Petioles:

The petiole of a grapevine is the slender stalk that connects the leaf blade to the stem. As it provides structural support and moves nutrients and water among the leaves and the rest of the plant, it is essential to the expansion and advancement of the grape plant. The quality of petioles in grape plants can be influenced by several factors, including genetics, environmental conditions, and cultural practices. Some of the factors that can affect the quality of grape petioles include:

1. Nutrition: Adequate and balanced nutrition is essential for the proper development of grape petioles. Nutrient deficiencies or excesses can affect the size, shape, and colour of petioles, as well as their ability to transport water and nutrients.
2. Water: Grape petioles require an adequate supply of water for proper growth and development. Drought stress or waterlogging can affect the quality of petioles and reduce their ability to transport water and nutrients.
3. Temperature: Temperature extremes can affect the growth and development of grape petioles. High temperatures can cause wilting, while low temperatures can cause damage to the petioles.
4. Pests and diseases: Grape petioles can be affected by various pests and syndromes, includes phylloxera, powdery mildew, and downy mildew. Petioles may become weakened or infected, which will impair their capacity to transfer water and vitamins.
5. Pruning: Improper pruning techniques can damage the petioles and reduce their ability to transport water and nutrients.

C. Research Problem:

Sunlight, water, and adequate nutrients are vital for plant growth. The sunlight and water are naturally accessible, but the soil minerals and nutrients required for plant growth are needed to be evaluated to ensure the growth of quality grapes. This research covers up 17 features based on soil, water, climatic condition, health of petiole and fruits nature. However, in all regions these nutrient is not readily available, thus making the growth of plants in these regions problematic. Farmers must work hard to identify nutritional deficiencies and replenish the necessary nutrients. Farmers find it difficult to determine the nutrients necessary for growing the fruits with high quality since the expected fruit output cannot be predicted. So, in this work, a machine learning model was established to aid the farmers in predicting the probability of growing a quality fruit based on soil nutrients, water nutrients, climatic nutrients, quality of petiole and fruits as the plant is cultivated. If this method is successful, we will be able to develop grapes with expected quality by helping the farmers to get a clear idea about the fertilizer to be used to obtain the necessitating quality.

D. Quality Analysis:

The five characteristics play a significant influence in how agriculture is produced and are controlled by its physical and chemical qualities. The ability of soil to support crucial ecosystem functions including intrinsic productivity, nutrient and water retention, and resistance to soil erosion and fertility deterioration are all related to the functional characteristics of soil. The cheap availability of open-source algorithms and the growing accessibility of soil data, which may be collected

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locally or remotely, have accelerated the application of machine learning (ML) techniques to analyse soil attributes.

In order to evaluate the soil and water nutrition, soil and water samples were gathered from each grape field and sent to a government testing lab to determine the minerals and nutrients available in it. Then following the collection of these data the climatic, quality of petiole and quality of grapes based data are collected and given to the machine learning platform was established for defining the quality, with the gathered sample soil data serving as the input. These machine learning platforms have classifiers that will aid in determining the nutritional content of soil.

In this work we have considered different classifiers as shown in figure 2 and data is given to each classifiers, and finally we will determine which classifier is more accurate in prediction the soil nutrient. The classifiers are:

1. Logistic Regression
2. KNN Classifier
3. Gaussian Naïve Bayes Classifier
4. Decision Tree Classifier
5. Random Forest Classifier
6. SVM Classifier

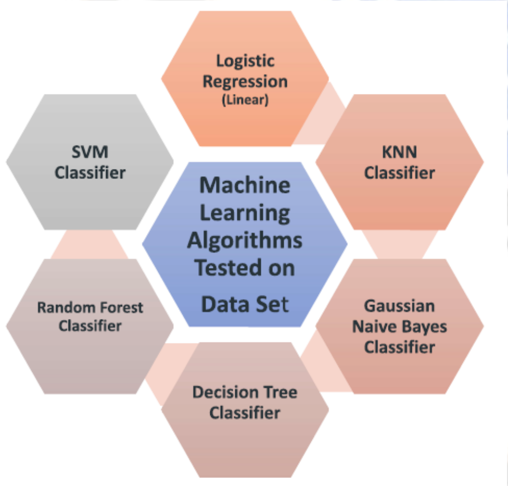

Figure 2. Machine Learning used for testing

5) Logistic Regression:

A type of statistical analysis called logistic regression is employed to estimate the likelihood of a binary result (yes or no, true or untrue, or 1 or 0). It is frequently employed in the area of ML for tasks involving binary classification, where the objective is to give every input data point a binary label. The logistic regression approach converts a linear mix of input variables into a probability value between 0 and 1 using a logistic function, commonly referred to as a sigmoid function. The logistic function's parameters are estimated by the procedure according to training data, and the cost function is used to calculate the discrepancy among the predicted likelihood and the actual binary labels After being trained, the logistic regression model may be utilised for predicting the likelihood of a binary result with fresh input data points. However, it has limitations in handling multi-class classification problems and can be sensitive to outliers in the data.

6) KNN Classifier:

KNN (k-nearest neighbours) is a ML classification technique that classifies a new data point based on its nearest neighbours in the training set. The KNN approach locates the K data points in the training set that are the closest to the new data point, and it classifies the new data point according to the majority class of its K nearest neighbours.

Working of KNN algorithms:

1. Choose the number of nearest neighbours (K) you want to use for classification.
2. Determine the separation among every information point in the training set and the new data point. Numerous techniques, including the Minkowski distance, Manhattan distance, and Euclidean distance, can be used to determine this distance.
3. Ascendingly sort the distances, then choose the K data points with the shortest distances.
4. Using the majority class of the new data point's K closest neighbours, determine its class.
5. If there is a tie in the majority class, you can use various tie-breaking methods such as selecting the class of the closest neighbour or randomly selecting one of the classes.
6. Repeat the process for each new data point that needs to be classified.

Although KNN is a simple and effective technique, it can be computationally expensive when dealing with huge datasets. Furthermore, the choice of K can have a significant impact on the algorithm's performance, hence it is critical to select the ideal value of K using cross-validation or other approaches.

7) Gaussian Naïve Bayes Classifier:

The Gaussian Naive Bayes classifier is a probabilistic ML-based classification method. It depends on the Naive Bayes theorem, which is a statistical method for calculating the likelihood of a hypothesis given certain observable evidence. The classifier determines the likelihood of each feature value for each class and assigns the highest likelihood to the class with the highest likelihood. However, it may not function properly if the independence condition is violated or the distribution of the features is not spherical.

8) Decision Tree Classifier:

ML methods called decision tree classifiers use a tree-like model to forecast the target variable based on a set of input

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features. The dataset as a whole is represented by the root node at the top of the tree; nodes beneath it is used to create subsets of the data based on the values for different attributes. A new data point is transmitted down the tree, followed by the branches determined by the feature values, until it reaches a leaf node, where a prediction is made. Decision tree classifiers are straightforward to understand and apply, can be applied to both classification and regression issues, and can handle both category and numerical inputs.

9) Random Forest Classifier:

A ML algorithm used for task classification is called the Random Forest Classifier. It is a type of ensemble learning that combines different decision trees to create a more accurate and trustworthy model. A random selection of training data and characteristics is used to train every tree, thereby reducing overfitting and boosting generalizability. The Random Forest Classifier has several benefits, such as the capacity to handle high-dimensional data and its resistance to over fitting, but it may not perform well on small datasets and may be difficult to interpret.

10) SVM Classifier:

SVM classifiers are used to identify the best hyper plane for dividing data classes. Support vectors are the points closest to the hyper plane, and SVM maximises the margin while minimising classification error. Both linearly separable and non-linearly separable data respond well to SVM. The ability to handle high-dimensional data, resilience to noise and outliers, and efficacy with small datasets are only a few advantages of SVM. For large datasets, it can be computationally expensive, and the regularisation parameter and kernel function choices can have an impact.

IV. Result And Analysis

Machine learning-based predictions of soil nutrients have enormous potential to advance farming and soil management techniques. In order to forecast the nutritional content of soil, machine learning algorithms may analyse vast quantities of data, including soil texture, soil pH, soil type, and plant nutrients. The accuracy and volume of the data utilised for analysis determine the outcomes of soil nutrient prediction using machine learning. The forecasts will be increasingly precise as more data becomes available. Additionally, machine learning algorithms can find relationships between various soil and environmental variables that could affect soil nutrient levels.

The capacity to create precise forecasts in real-time is one of the key advantages of utilising machine learning to predict soil nutrients. Soil nutrient levels may now be immediately evaluated by farmers and land managers, who can then modify their management techniques as necessary. Neural networks, decision trees, and random forests are a few machine learning techniques that may be used to the prediction of soil nutrients. The acquired data set is entered into multiple machine learning algorithms in this study, including SVM Classifier, Logistic Regression Classifier, KNN Classifier, Gaussian Naive Bayes Classifier, Decision Tree Classifier, and Random Forest Classifier. Finally, we may draw the conclusion that the soil nutrient forecast accuracy increases depending on which machine learning method is used.

A. Soil Nutrient Various Village Sample:

Plant development and growth depend on the nutrients in the soil. The two categories of soil nutrients that are crucial for plant growth are macro and micro nutrients. Macronutrients are those that plants need in high concentrations. These three elements—nitrogen (N), phosphorus (P), and potassium (K)—are the main macronutrients. The most often examined nutrients in soil samples are these three, together known as NPK.

Micro nutrients, on the other hand, are nutrients that are required in smaller amounts by plants, but are still important for their growth and development. Some examples of micro nutrients include iron (Fe), manganese (Mn), zinc (Zn), boron (B), copper (Cu), and molybdenum (Mo). To collect soil samples for nutrient testing, we used a soil probe or a spade to collect soil from 154 villages in Nasik Maharashtra.

Mix the soil samples thoroughly in a clean container, remove any rocks or debris, and air-dry the soil before sending it to a soil testing lab for analysis. To know the percentage of soil nutrients in the farms the collected sample was taken to the laboratory test in Maharashtra Rajya Draksha Bagaitdar Sangh (MRDBS). After the testing reports are given which contain information on the nutrient levels in your soil and recommendations for any necessary soil amendments to improve plant growth. The total soils macro and micro nutrient are shown in figure.3 and figure.4.

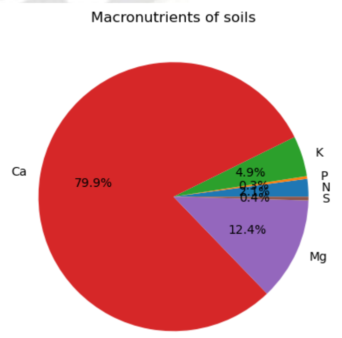

Figure 3: Macronutrients of Soils

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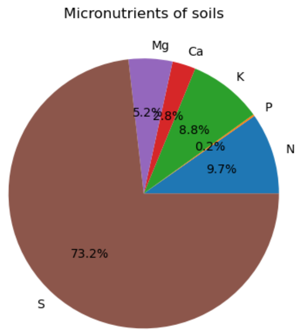

Figure 4: Micronutrients of Soils

B. *Sample Collected in Pimpalas Ramache:*

Pimpalas Ramache, a small village in the Nasik District of Maharashtra, is one of the almost 154 villages from where soil samples were collected. In comparison to other village soil, the nutrients in this soil are more than enough for the grape to grow successfully. Figure 5 and figure.6 shows the results of the MRDBS test on a soil sample taken from Pimpalas Ramache.

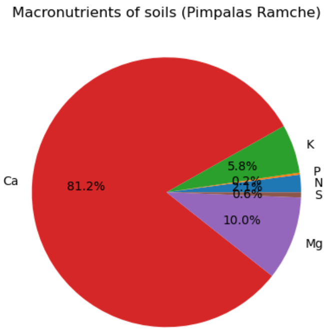

Figure 5: Macronutrients of Soils (Pimpalas Ramche)

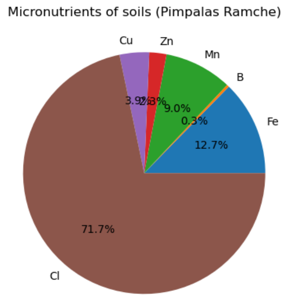

Figure 6: Micronutrients of Soils (Pimpalas Ramche)

C. *Correlation Between Nutrients:*

The interactions between the numerous different soil nutrients that might impact plant growth and development can be intricate. Some broad trends in the link between soil nutrients have been found, though. For instance, because plants need them in relatively high amounts, the "primary nutrients" nitrogen, phosphorous, and potassium are sometimes referred to as. Larger levels of one nutrient frequently indicate larger levels of the other two because these three nutrients are generally connected with one another in soil.

TABLE I CHEMICAL PROPERTIES OF NUTRIENT IN PIMPALAS RAMCHE

	N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**B**	**Mn**	**Zn**	**Cu**	**Cl**
N	0	0.69	-0.19	0.54	0.37	-0.57	-0.37	-0.4	0.63	0.52	0.78	0.58
P	0.69	0	-0.32	0.35	0.79	-0.18	-0.42	0.04	0.16	-0.17	0.2	0.22
K	-0.19	-0.32	0	-0.46	0.19	0.33	0.67	0.29	-0.62	0.44	0.29	0.28
Ca	0.54	0.35	-0.46	0	0.21	-0.89	0.11	-0.91	0.63	0.23	0.36	0
Mg	0.37	0.79	0.19	0.21	0	-0.02	0.17	0.11	-0.33	-0.14	0.13	0.15
S	-0.57	-0.18	0.33	-0.89	-0.02	0	-0.12	0.9	-0.61	-0.53	-0.44	0.09
Fe	-0.37	-0.42	0.67	0.11	0.17	-0.12	0	-0.27	-0.49	0.27	0.06	-0.15
B	-0.4	0.04	0.29	-0.91	0.11	0.9	-0.27	0	-0.66	-0.46	-0.46	-0.04
Mn	0.63	0.16	-0.62	0.63	-0.33	-0.61	-0.49	-0.66	0	0.32	0.52	0.37
Zn	0.52	-0.17	0.44	0.23	-0.14	-0.53	0.27	-0.46	0.32	0	0.82	0.43
Cu	0.78	0.2	0.29	0.36	0.13	-0.44	0.06	-0.46	0.52	0.82	0	0.81
Cl	0.58	0.22	0.28	0	0.15	0.09	-0.15	-0.04	0.37	0.43	0.81	0

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The correlation between different nutrients are shown in Figure.7

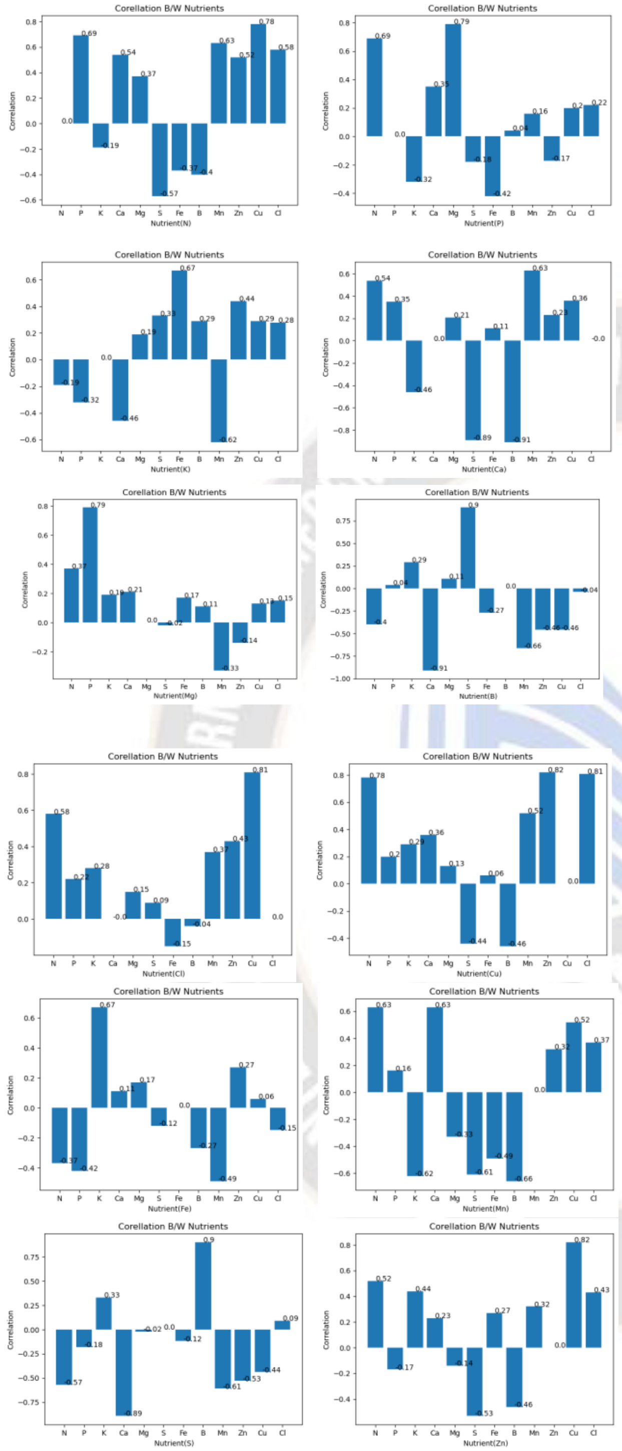

Figure 7: Correlation between different nutrients

Similar to these other elements, calcium, magnesium, and sulphur are also crucial for plant growth and are sometimes referred to as "secondary nutrients." Additionally, the quantities of these nutrients in soil are typically connected, with higher levels of one nutrient implying larger levels of the others. The term "micronutrients" refers to other nutrients that plants need in much lower levels, such as iron, zinc, manganese, and copper as shown in figure 7. Because some micronutrients are more readily available to plants in some soil conditions than others, the connections between these nutrients in soil can also be complicated. The overall chemical properties available in Pimpalas Ramche is shown in Table.1

D. Comparison Based On Machine Learning Algorithms:

The next part compares different machine learning methods to determine which data set has produced the most accurate predictions of soil nutrient levels. For this project, we have used six different classifiers: SVM, Decision Tree, Random Forest, Gaussian Naive Bayes, and Logistic Regression. The comparison accuracy of each classifier has been shown in Figure.8 and Table.2

TABLE II COMPARISON OF DIFFERENT CLASSIFIERS

CLASSIFIER	ACCURACY
Logistic Regression	0.7780678851174935
K Nearest Neighbour	0.4804177545691906
Support Vector Machine (Linear Classifier)	0.9608355091
Support Vector Machine (RBF Classifier)	0.46475195822454307
Gaussian Naive Bayes	0.8772845953002611
Decision Tree Classifier	1.0
Random Forest Classifier	0.9895561357702349

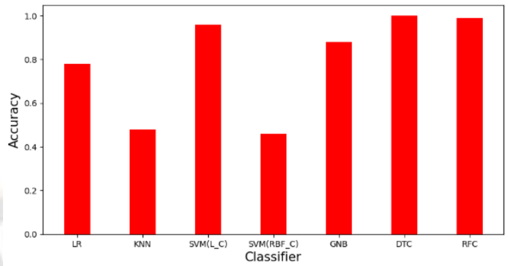

Figure 8: Comparison graph for different classifier

From the graph shown in fig 8, we can see that when comparing to other classifier the decision tree classifier is showing 100% accuracy.

V. CONCLUSION:

This study found significant differences in soil nutritional characteristics among planting regions, planting ages, and farmed grape varieties in 154 selected vineyards in Nasik, Maharashtra. The findings imply that planting area and planting age are the most significant variables affecting soil nutrient features, whereas planted grape varieties had no discernible

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influence on these features. The chosen vineyards' soil pH only responded to the planting area and did not directly correlate with the age of the vines or the grape variety. The Pimpalas Ramche contains more nutrients for the grape to grow more successfully based on samples gathered from different vine yards. The suggested method predicts the quantity of macro- and micronutrients determined in the laboratory using leaf spectral data in the visible and near-infrared regions, switching between reflectance and its first-derivative data. Logistic Regression (0.778), K Nearest Neighbour (0.48), Support Vector Machine (Linear Classifier) (0.96), Support Vector Machine (RBF Classifier) (0.464), Gaussian Nave Bayes (0.877), Decision Tree Classifier (1.0), and Random Forest Classifier (0.989) are the accuracy results for different classifiers. The Decision Tree Classifier outperforms all other classifiers in terms of accuracy.

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