

Soil and Crop Recommendation

SAMIE AHMAD



Literature Review

The Future of Digital Agriculture: Technologies and Opportunities

Fountas, Spyros, et al.

Deep Learning in Agriculture: A Survey

Kamilaris, Andreas, and Francesc Prenafeta Boldú

Big Data in Smart Farming – A Review

Wolfert, Sjaak, et al.

Visible, Near Infrared, Mid Infrared or Combined Diffuse Reflectance

Viscarra Rossel, Raphael, et al.

Exploring Machine Learning Models for Soil Nutrient Properties:

Folorunso, Olusegun, et al.

Advancements in Crop Yield Prediction Using Deep Learning Algorithms

Ajina, A., et al.

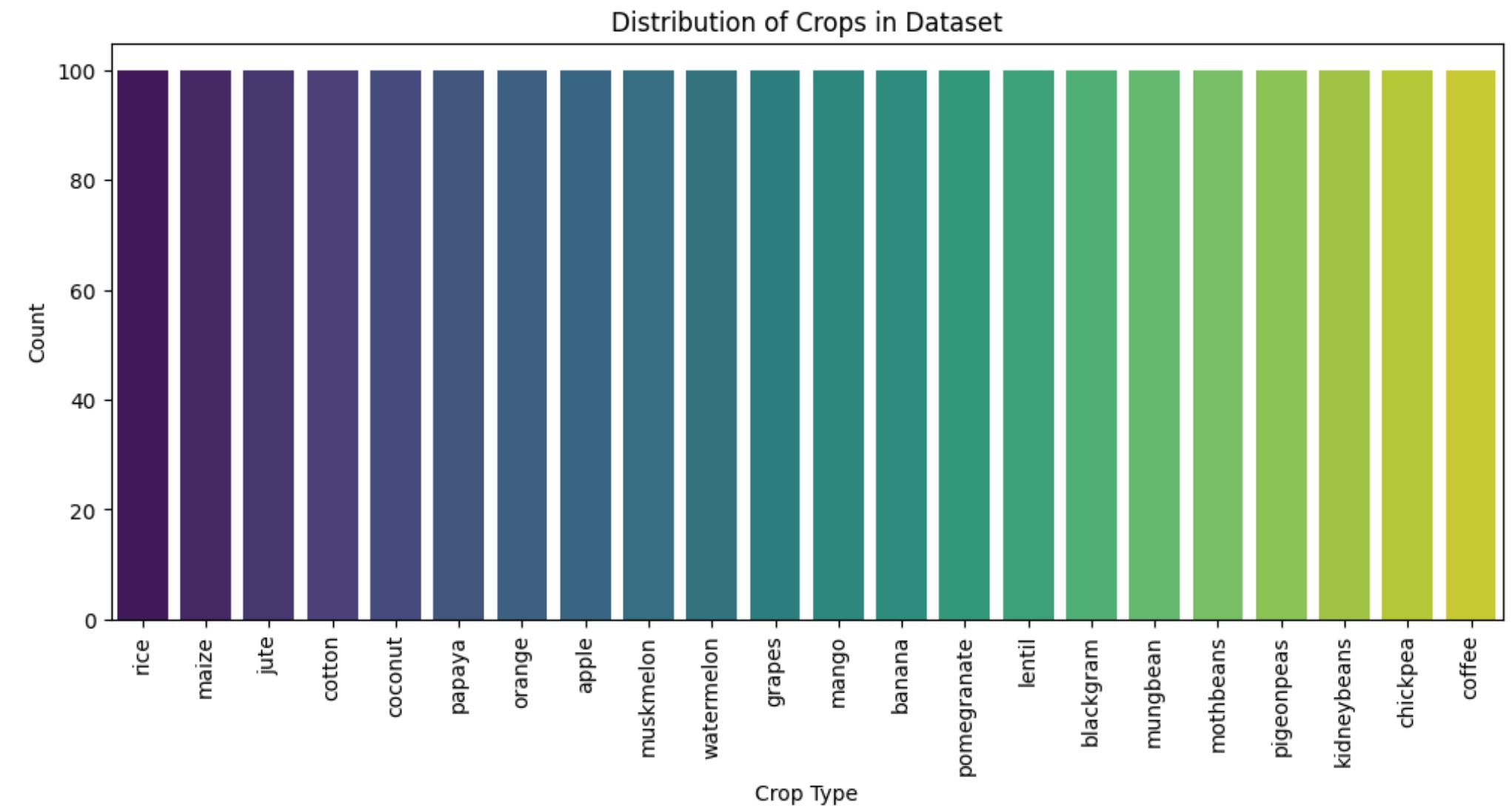
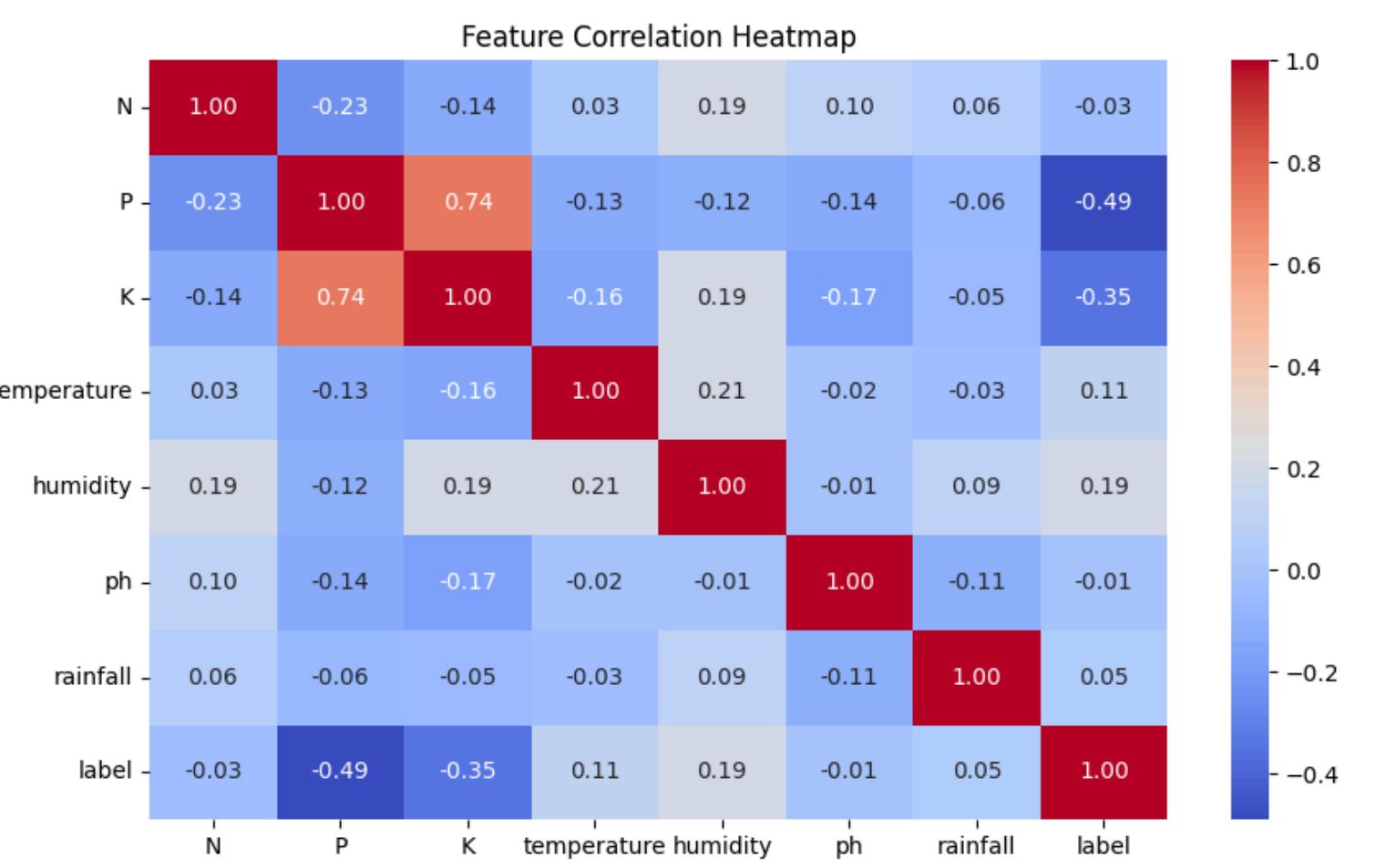
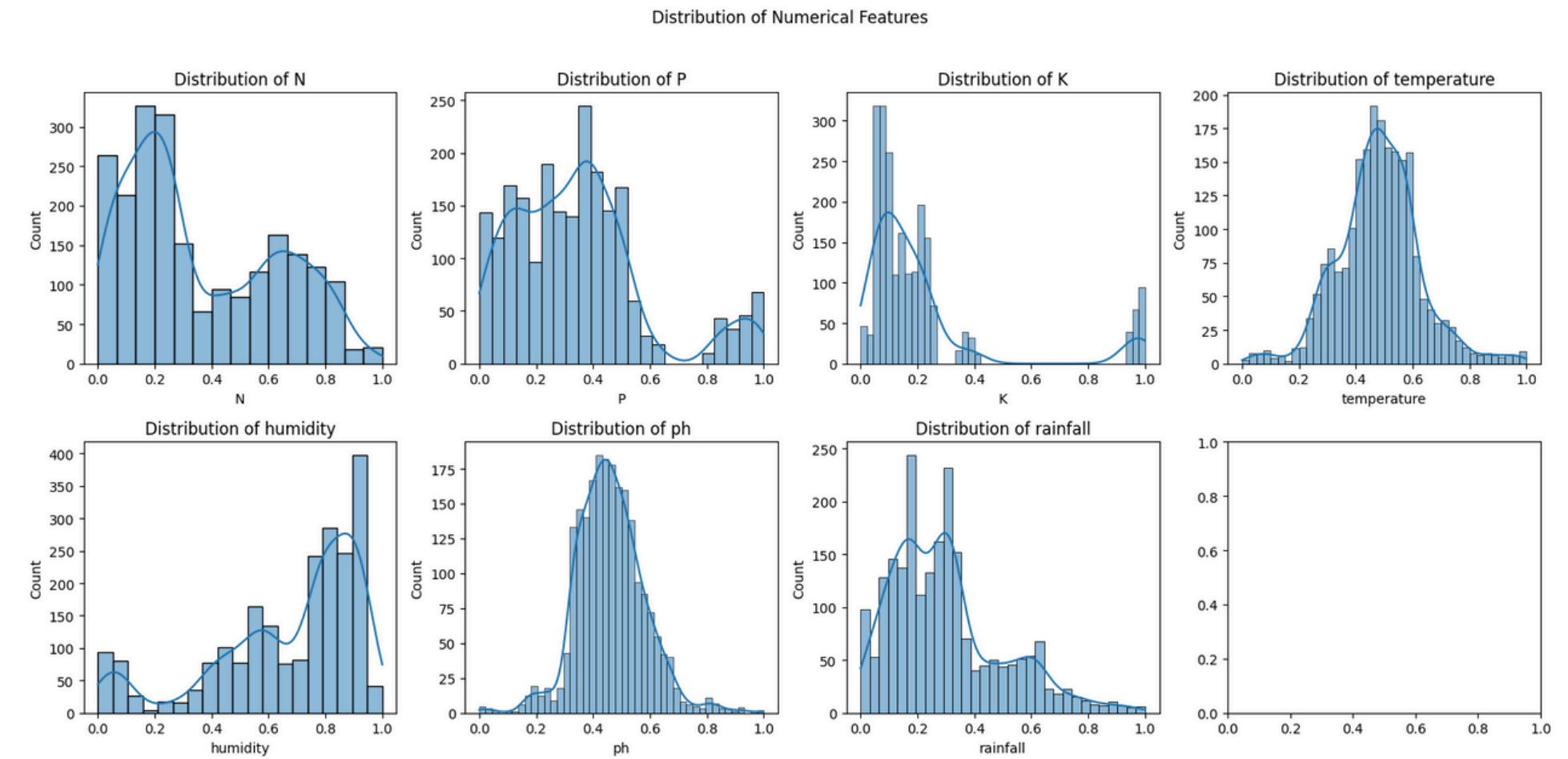
A Comprehensive Review on Automation in Agriculture Using AI

Jha, Kirtan, et al.



The Dataset

This dataset contains labels for the recommended crop based on the distribution of minerals in soil, pH and humidity.



Model Implementation

Random Forest Classifier was chosen for its robustness and efficiency

Preprocessing

- Data Cleaning
- Feature Scaling
- Label Encoding
- Train-Test Split (80:20)

Optimized Hyperparameters

- n_estimators = 300
- max_depth = 25
- min_samples_split = 4
- min_samples_leaf = 2



Evaluation

High Model Accuracy

The model achieved 99.32% accuracy, indicating strong predictive performance.

Minimal Misclassification

The confusion matrix shows that most crops were classified correctly.

Feature Importance & Correlations

Soil nutrients (N, P, K), temperature, and humidity played a significant role in crop prediction.



99.3% ACCURACY

93.4% PRECISION

93.3% RECALL

93.3% F1 SCORE

Model Phase 2



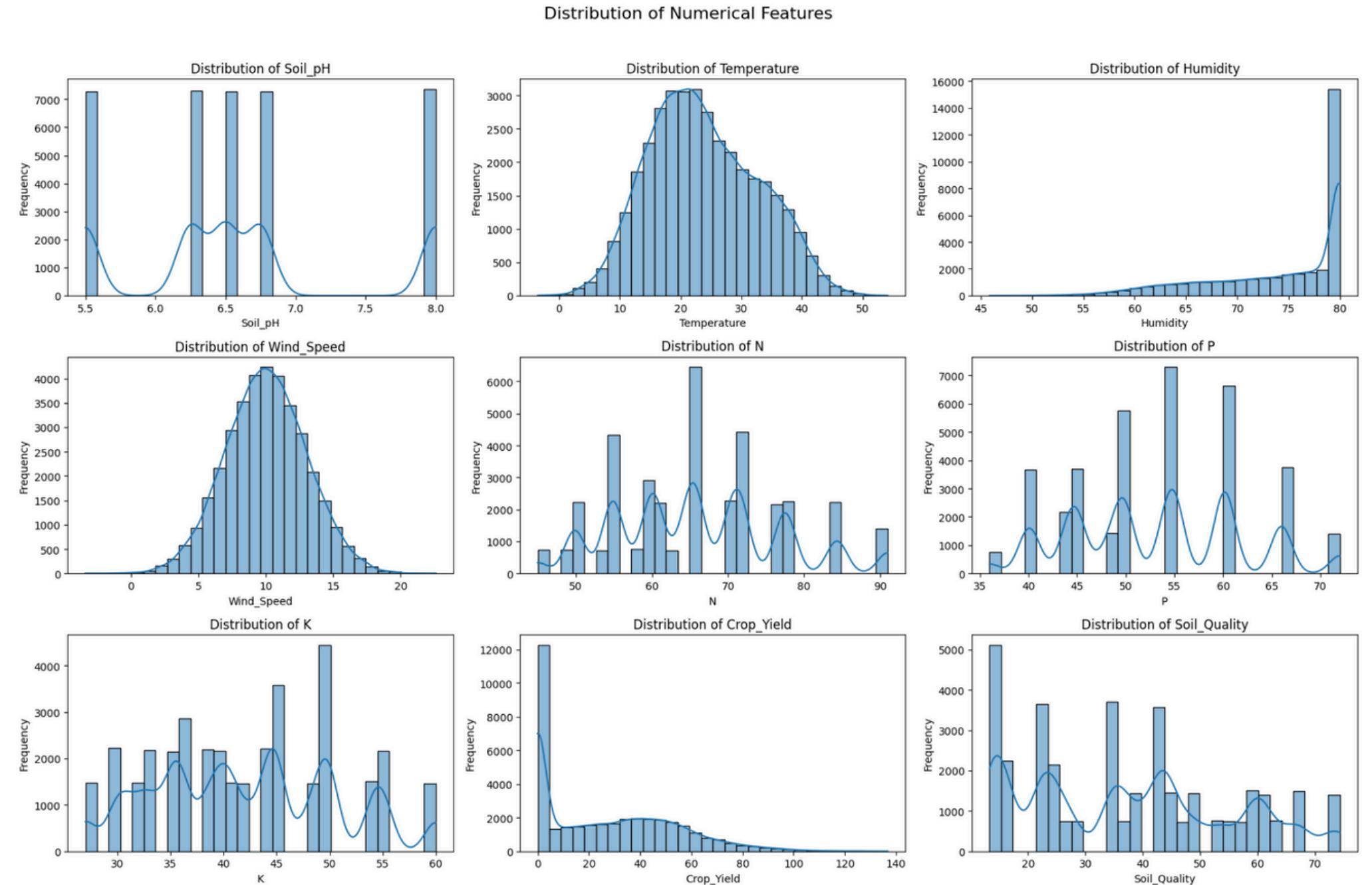
New DataSet Review

- Entries: 36,520 rows**
- Features: Soil pH, Temperature, Humidity, Wind Speed, N, P, K, Soil Quality, Soil type, Crop Type, Crop Yield**
- Date Range: 2014 – 2023**
- Crop Types: 10**
- Soil Types: 5**

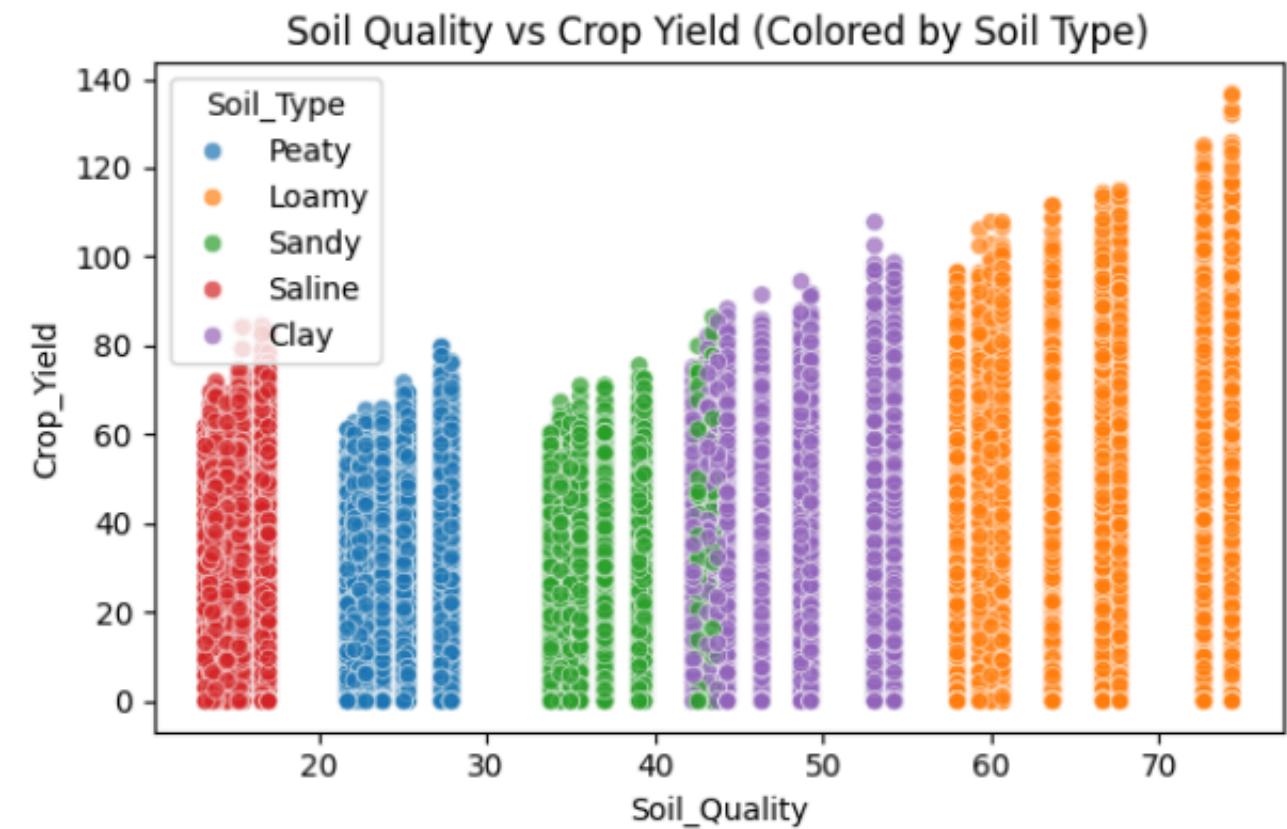


Exploratory Data Analysis

- Right-skewed nutrient and yield values.
- Soil pH centers around neutral (6.5–7.5).



Exploratory Data Analysis

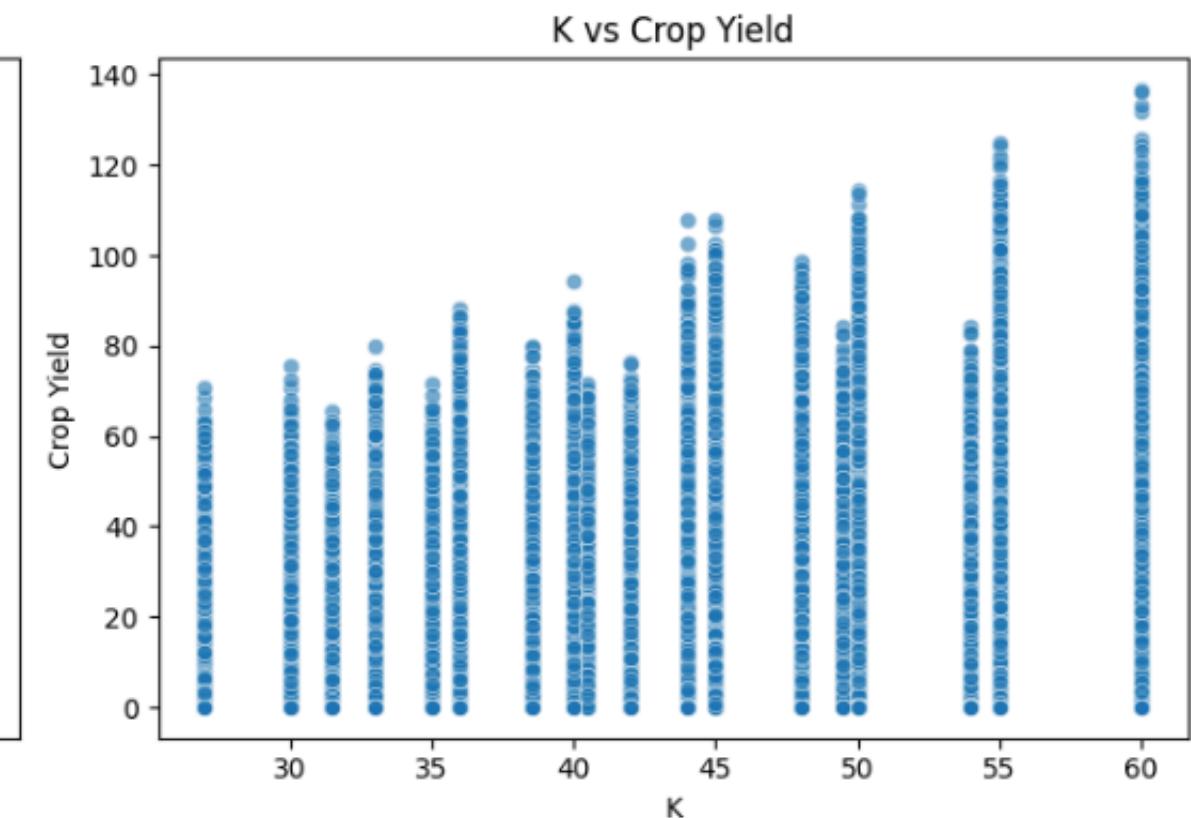
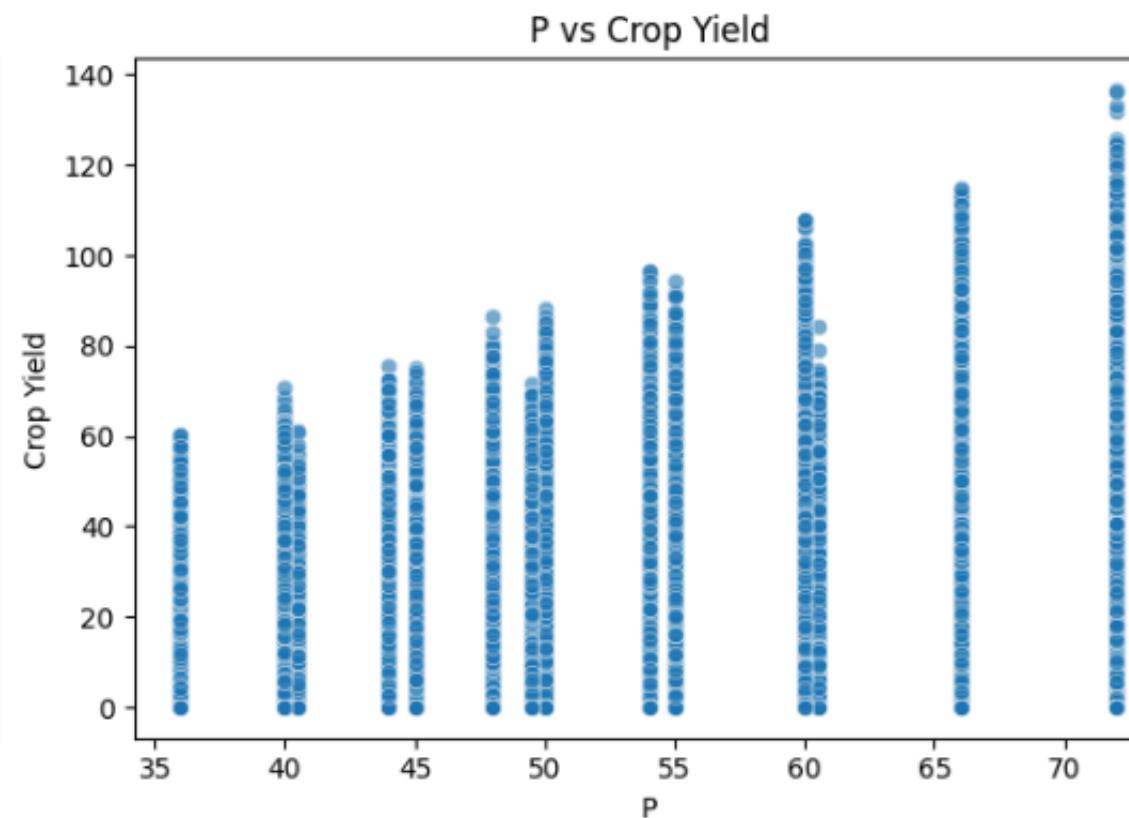
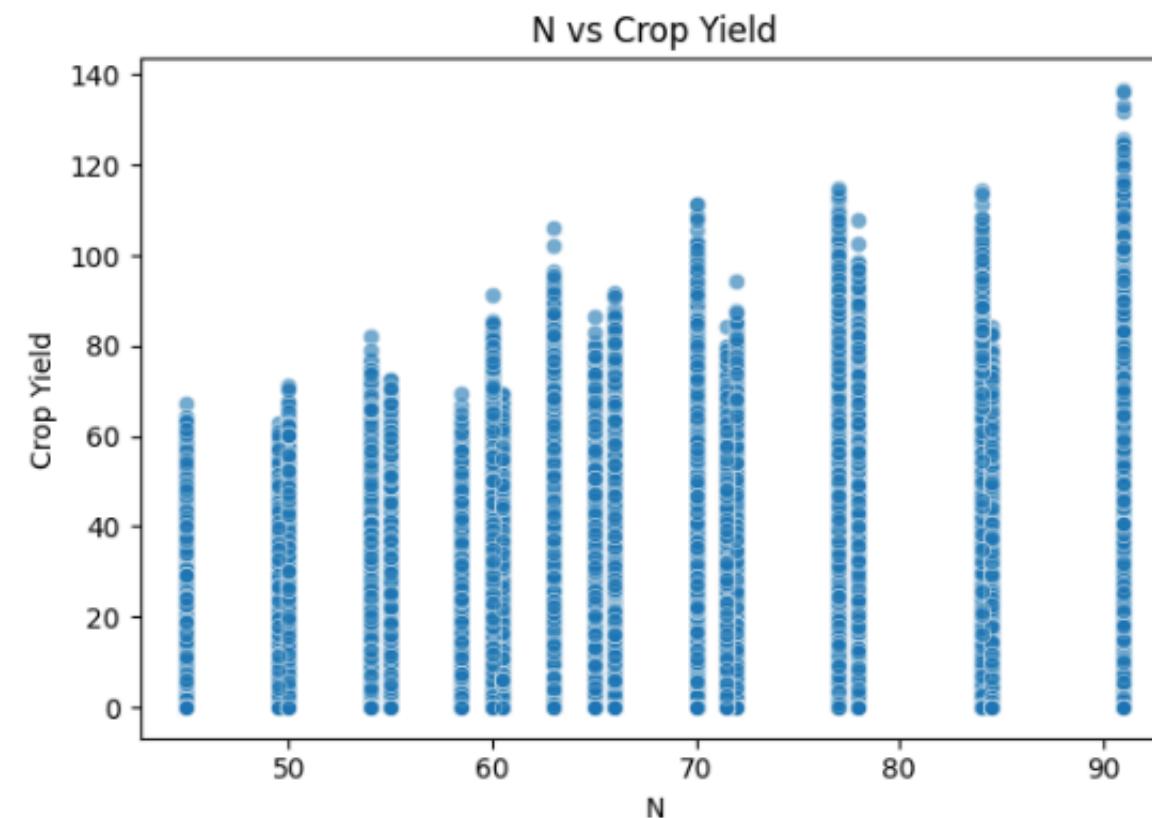


Soil Quality vs. Yield

- Positive trend between soil quality and crop yield.
- Soil Type influences this relationship.

NPK vs Crop Yield

- Yield increases with nutrients up to a threshold.
- After a certain level, yield stabilizes or drops → non-linear effect.

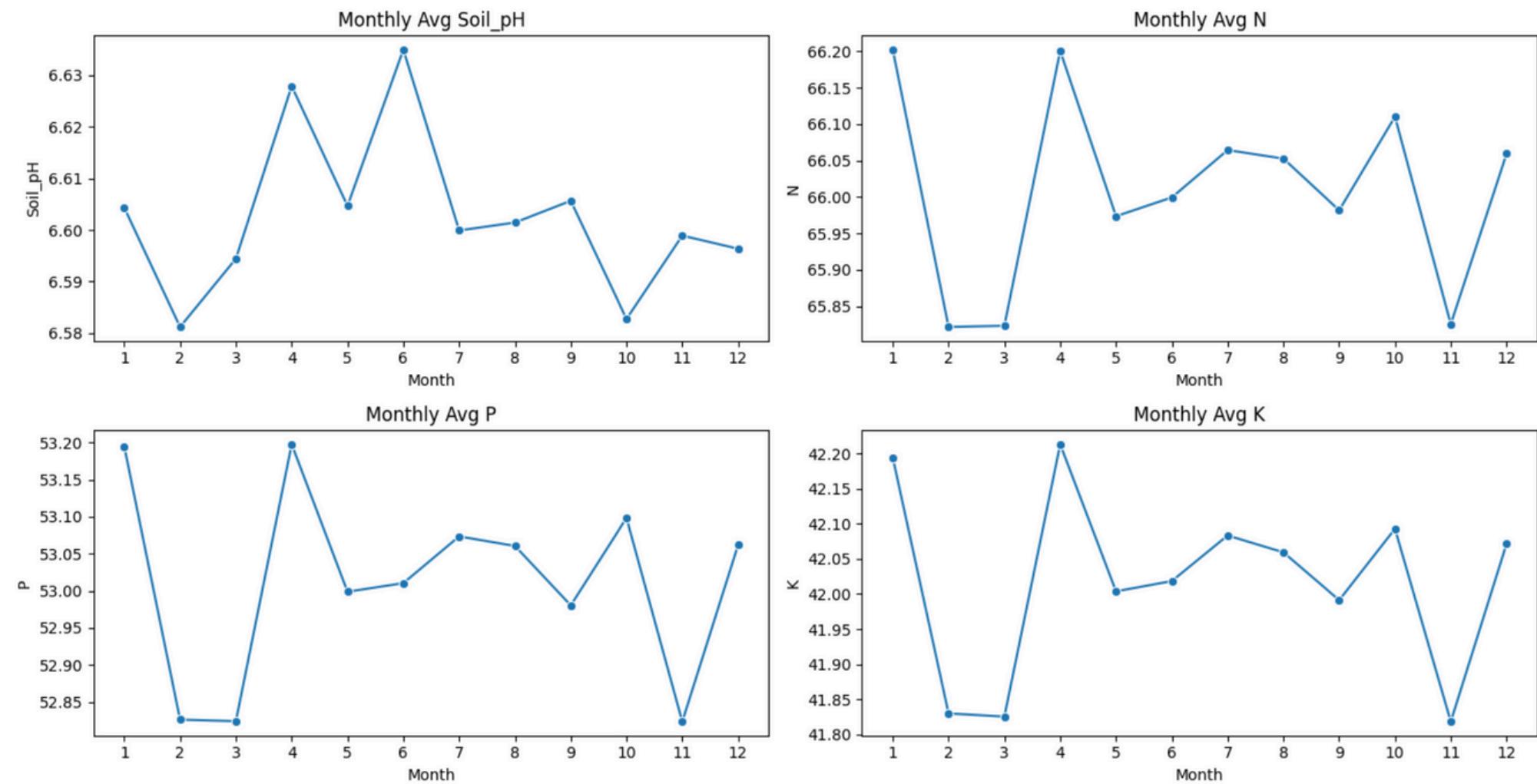


Temporal Analysis

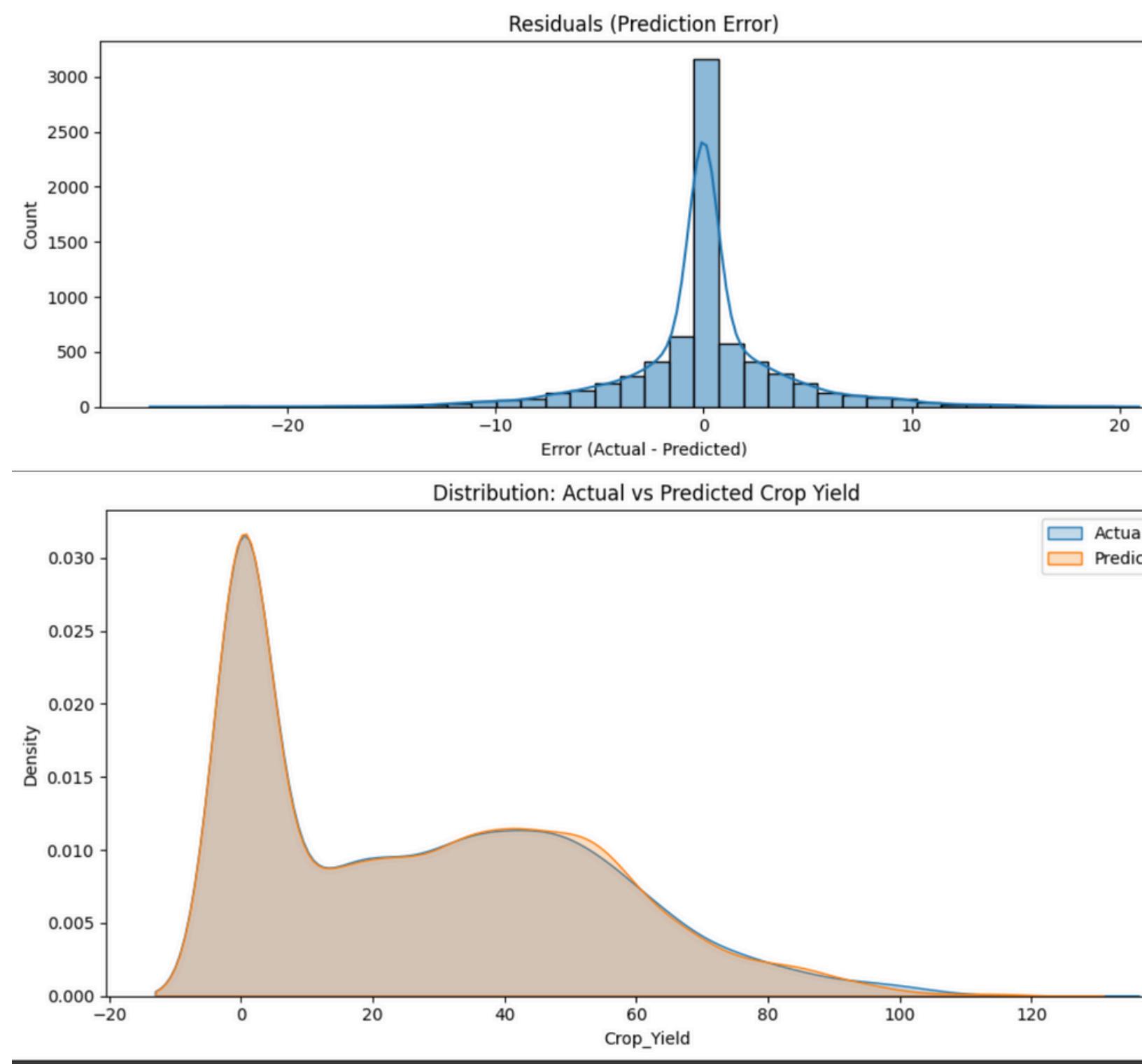
- N, P, and K levels throughout the year range from 6.58-6.64 - a neutral range ideal for most crops.
 - Nutrient spikes around April-June.
 - Dips in February and November, suggesting these months are less fertile.
 - These patterns likely reflect fertilizer application cycles or natural soil respiration.

Implications:

- Best months for planting: April to July, when nutrient levels peak.
- Avoid planting in February or November unless fertilizer intervention is planned.
- These trends could be used to simulate fertilization calendars or time-aware crop recommendation systems.



Regression Using XGBoost and Random Forest pipelines

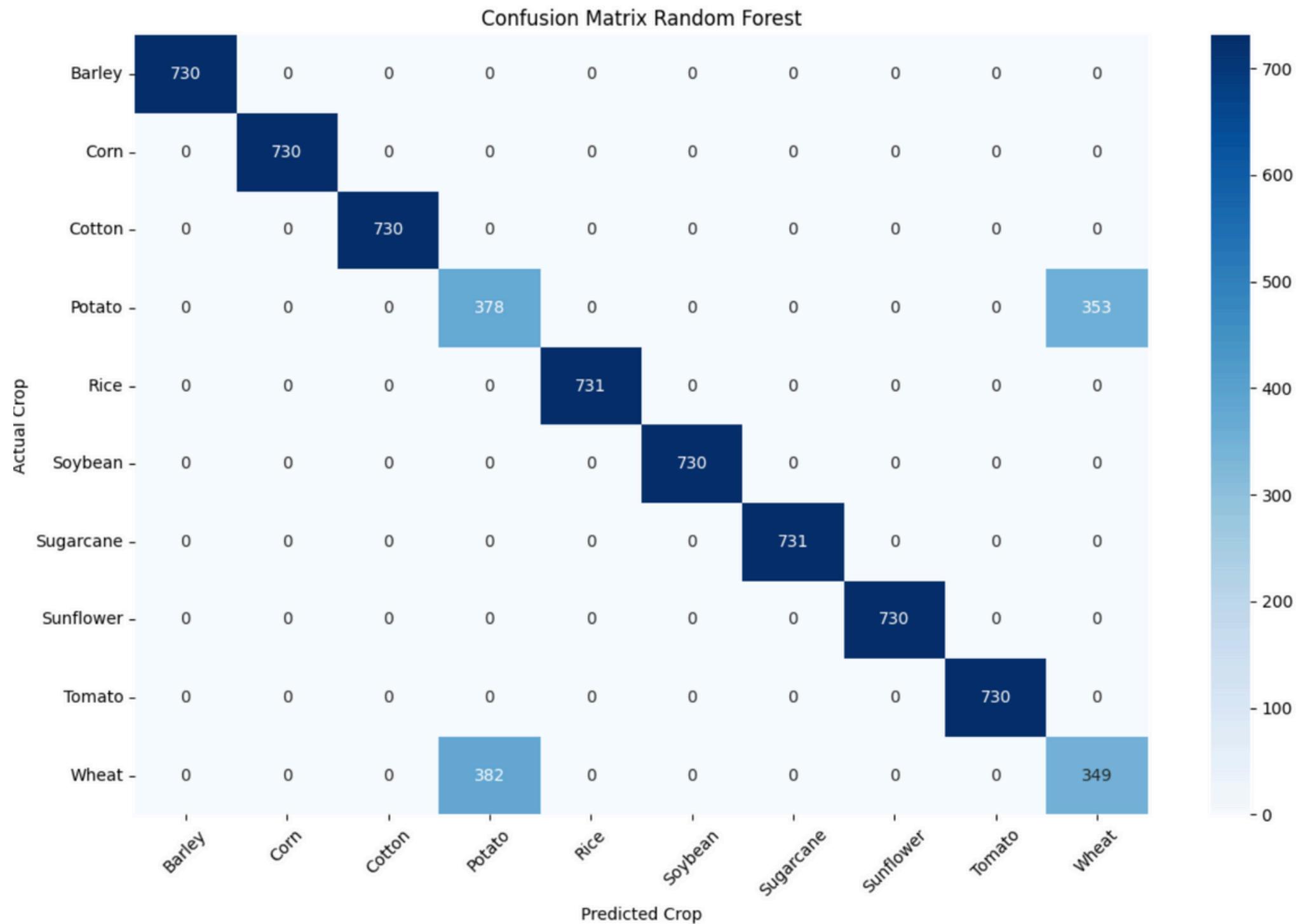


Random Forest -
RMSE: 16.12,
MAE: 2.34,
R²: 0.9758

XGBoost -
RMSE: 17.21,
MAE: 2.56,
R²: 0.9742

Prediction Model Implementation

- **Model: Random Forest**
- **Accuracy: 89.9%**
- **Top-2/Top-3 Accuracy: 100%**
- **Confusion Matrix: Good prediction for most crops**
- **Struggles with: Potato, Wheat**



Implementation of Portal - AgriPRO



- Built Front End using HTML
- Backend using Flask
- Model tweeked and deployed
- Named the portal AgriPRO

A screenshot of a web browser window showing the AgriPRO application. The address bar displays "127.0.0.1". The title bar says "AgriPro — Home". The page features a large background image of a windmill in a field of colorful tulips under a blue sky. At the top left is the AgriPRO logo. Below the logo is a section titled "About AgriPro" with the subtext "Learn how AgriPro uses AI to empower smarter agriculture." and a "Learn More" button. To the right is a section titled "Start Predicting" with the subtext "Input your land conditions and discover which crops are best for your field." and a "Try Now" button. There are also two smaller images: one of a close-up flower and another of a person in a field.

Implementation of Portal - AgriPRO

- User fills a form entering details for prediction
- The Top 3 crops based on the data are suggested
- Made bespoke icons for each crop in database, for a better visual experience
- Scores for each crop also returned
- Explanation Module

The screenshot shows the AgriPRO Crop Recommendation System interface. At the top, there's a navigation bar with tabs for "OpenRouter API Troubleshooting", "Crop Recommendation System", and a link to "https://arxiv.org/pdf/1706.0". The main header says "agriPRO". On the left, a "Crop Predictor" form is displayed with fields for soil type ("Loamy") and eight numerical inputs (6, 20, 80, 8, 15, 30, 30, 30). Below the form are four cards: "TOMATO" (red background, image of a tomato), "SOYBEAN" (green background, image of a soybean pod), "WHEAT" (tan background, image of a wheat ear), and a summary card with a list of crops and their scores: Tomato — Score: 1.3, Soybean — Score: 1.06, Wheat — Score: 0.28. At the bottom, a section titled "Why These Crops?" explains the selection based on environmental and soil factors, mentioning Tomato's adaptability to cooler climates.

Crop Predictor

Loamy

6

20

80

8

15

30

30

30

Predict Reset

TOMATO

SOYBEAN

WHEAT

- Tomato — Score: 1.3
- Soybean — Score: 1.06
- Wheat — Score: 0.28

Why These Crops?

The selection of Tomato, Soybean, and Wheat as optimal crops under the given conditions can be explained by their adaptability to the environmental and soil factors provided:

1. Tomato

- **Temperature (Low):** Certain tomato varieties (e.g., determinate/cold-tolerant types) thrive in cooler climates, especially if frost risks are managed.

DeepSeek Explainability Module

- **Model: R1**
- **Used to explain how the crops that were selected are indeed the best option**
- **Works hand in hand with prediction model**
- **Integrated via System Prompt and API**

The screenshot shows a web-based application titled "agriPRO" under the "Crop Recommendation System". The URL in the address bar is "https://arxiv.org/pdf/17". The page displays a section titled "Why These Crops?" explaining the selection of Tomato, Soybean, and Wheat as optimal crops based on environmental and soil factors.

Why These Crops?

The selection of Tomato, Soybean, and Wheat as optimal crops under the given conditions can be explained by their adaptability to the environmental and soil factors provided:

1. Tomato

- **Temperature (Low):** Certain tomato varieties (e.g., determinate/cold-tolerant types) thrive in cooler climates, especially if frost risks are managed.
- **Humidity (High):** While high humidity can promote fungal diseases (e.g., blight), tomatoes tolerate humid conditions better than many crops if disease-resistant varieties are chosen or airflow is adequate.
- **Soil pH (Low):** Tomatoes prefer slightly acidic soil (pH 5.5–6.8), aligning with the low pH here.
- **Soil Quality & Type (High, Loamy):** Loamy soil retains moisture and nutrients efficiently, supporting tomato root development and fruit production.
- **Nutrients (N-P-K = 30):** Moderate potassium (K) supports fruit quality, while phosphorus (P) aids root growth. Nitrogen (N) promotes foliage, though excess can reduce yields—moderate levels here are optimal.

2. Soybean

- **Temperature (Low):** Soybeans are adaptable and can grow in cooler temperatures (e.g., short-season varieties).
- **Humidity (High):** They tolerate humidity well, though excessive moisture during podding may require drainage.
- **Soil pH (Low):** Soybeans prefer pH 6.0–7.0 but can tolerate mildly acidic soils (pH ≥5.5). Nitrogen-fixing rhizobia bacteria (symbiotic with soybeans) also adapt to slightly acidic conditions.
- **Soil Quality & Type (High, Loamy):** Loam supports their deep root system, and high soil quality ensures nutrient availability despite their nitrogen-fixing capability.
- **Nutrients (N-P-K = 30):** Soybeans require less external nitrogen (N) due to symbiotic nitrogen fixation, while moderate phosphorus (P) and potassium (K) support pod development.

3. Wheat

- **Temperature (Low):** Cool-season wheat varieties (e.g., winter wheat) grow well in low temperatures and can withstand frost.
- **Humidity (High):** Wheat is less prone to humidity-driven diseases compared to broadleaf crops, though proper spacing and airflow mitigate mold risks.
- **Soil pH (Low):** Wheat tolerates mildly acidic soils (pH 5.5–7.0), aligning with the low pH here.
- **Soil Quality & Type (High, Loamy):** Loamy soil provides excellent drainage and nutrient retention, critical for wheat's root growth and grain yield.
- **Nutrients (N-P-K = 30):** Moderate nitrogen (N) supports tillering, while phosphorus (P) aids root development and potassium (K) enhances stress tolerance.
- **Wind Speed (15 units):** Wheat's sturdy stems and narrow leaves reduce wind damage risk, unlike taller, broadleaf crops.

Key Synergies

- **Soil Quality & Loam:** All three crops benefit from loam's balance of drainage and moisture retention, enhanced by high organic matter.
- **Climate Resilience:** Cool temperatures and humidity are managed through crop-specific traits (e.g., disease resistance in tomatoes, nitrogen fixation in soybeans, hardiness in wheat).
- **Nutrient Efficiency:** Moderate N-P-K levels align with these crops' needs, avoiding over-fertilization risks (e.g., excessive nitrogen reducing tomato yields).

These crops collectively optimize the given conditions while mitigating potential challenges like acidity and humidity through natural adaptability or management practices.

Going forward

- More feature engineering
- Sorting out the issues with Tier 1 and Tier 2 crops
- Integrating more AI based insights on the portal

