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Agrigen: Revolutionizing Agriculture with Generative AI

Dr. Pooja Aspalli [1], Rakshita Malaghan [2], Ratnamma [3], Syeda Sidra Quadri [4]

[1]Assistant Professor, [2]Student, [3]Student, [4]Student

Dept. of Computer Science and Engineering, Poojya Doddappa Appa College of Engineering, Kalabuargi, India

poojaaspalli@pdaengg.com[1], rakshithamalaghan02@gmail.com[2], gurunathgurunath168@gmail.com[3],sidraquadri71@gmail.com[4]

ABSTRACT—

Agriculture today faces serious problems that farmers have been struggling with for years. Many farmers still pick crops based on the traditional practices, without knowing if their soil can actually support those choices. When diseases hit their crops, they often don't recognize the signs until it's too late, leading to massive losses that can destroy entire harvest. Getting advice from agricultural experts is nearly impossible for farmers in remote areas, leaving them to make critical decisions alone. Our research tackles these issues head-on with AgriGen, a smart farming system powered by artificial intelligence that acts like having an agricultural expert in your pocket. The system works through three main parts that farmers actually need. First, it looks at what's in your soil - the nitrogen, phosphorus, and potassium levels - and tells you which crops will grow best there, not just what you've always planted. Second, it can look at pictures of sick plants and figure out what disease is attacking them, then suggest exactly which fertilizers will fix the problem. Third, it includes a chatbot that can answer any farming question you throw at it, from when to plant seeds to how to deal with pests. This isn't just another tech project - it's a practical tool that can help farmers grow more food, lose fewer crops to disease, and make farming profitable again.

***Index Terms*— Generative AI, Crop Recommendation, Disease Detection, Agricultural Chatbot**

I. INTRODUCTION

Farming has always been tough work, but these days it feels like farmers are fighting an uphill battle they can't win. Climate changes with droughts hitting when crops need water most and floods washing away months of hard work. At the same time, the world population keeps growing, putting pressure on farmers to produce more food from the same amount of land. But here's the real problem - most farmers are still making decisions the way their ancestors did, relying on gut feelings and family traditions instead of science. This approach worked fine when farming was simpler, but today's challenges need modern solutions. Take crop selection, for example. A farmer might grow rice every year because that's what his family has always done, even though his soil might be perfect for growing something more profitable like cotton or sugarcane. Or consider plant diseases - by the time a farmer notices yellow leaves or spots on his crops, the disease has often spread so far that half the harvest is already lost. Agricultural experts are expensive and hard to find, especially in rural areas where most farming happens. A farmer with a sick crop might have to travel for hours just to find someone who can tell him what's wrong, and by then it's often too late to save the harvest. The internet has tons of farming information, but most of it is written in technical language that regular farmers can't understand, or it's meant for crops grown in completely different climates. This is where technology can make a real difference. Computers are getting smart enough to look at soil test results and recommend the best crops to plant. They can examine pictures of diseased plants and identify problems faster than human experts. They can answer farming questions instantly, any time of day or night. The challenge has been putting all these capabilities together in a way that's simple enough for busy farmers to actually use. That's exactly what we set out to do with AgriGen.

1. Crop Recommendation Module

Every farmer knows that soil is everything, but most don't really understand what makes soil good or bad for different crops. They might know their field grows decent wheat, but they have no idea whether that same soil could grow amazing tomatoes or terrible corn. The secret is in three nutrients that plants need most - nitrogen for green growth, phosphorus for strong roots, and potassium for disease resistance. The problem is that getting your soil tested usually means sending samples to a lab and waiting weeks for results that come back as a bunch of numbers that don't mean much to the average farmer.

Our crop recommendation system changes all that by turning those confusing numbers into clear advice about what to plant. When a farmer gets his soil test results showing nitrogen, phosphorus, and potassium levels, he just plugs those numbers into our system. These digital farmers have seen thousands of different soil types and know exactly which crops succeeded or failed in each one. The system doesn't just tell you what to plant - it explains why. Maybe your soil has plenty of nitrogen but lacks phosphorus, making it perfect for leafy vegetables but terrible for fruit trees. Or perhaps your potassium levels are through the roof, which means root vegetables would thrive there. The best part is that the system gets smarter as more farmers use it, learning from their successes and failures to make even better suggestions.

2. Disease Detection and Fertilizer Recommendation Module

Picture this - a farmer notices some strange spots on his tomato plants. In the old days, he'd have to describe these spots to other farmers or try to find an agricultural expert, hoping someone could tell him what was wrong. By the time he figured it out and got the right treatment, he might lose half his crop. Plant diseases are sneaky that way - they start small and spread fast, and different diseases can look very similar to untrained eyes.

Our disease detection module works like having a plant doctor in your smartphone. A farmer just takes a picture of the sick plant with his phone camera, and our system examines that image more carefully than any human could. We have trained our computer using thousands of pictures of diseased plants, showing it exactly what bacterial infections look like versus fungal problems versus insect damage. The system uses deep learning, which means it builds up its knowledge layer by layer, first recognizing basic patterns like leaf shapes and colors, then more complex signs like the way disease spots spread or how leaves curl when attacked by specific pests. What makes this really useful is that we don't just identify the disease - we immediately suggest the exact fertilizer or treatment needed to fix it. The system knows that bacterial wilt needs copper-based fungicides while nutrient deficiencies need specific fertilizer blends. It even considers what stage the crop is in, because treating a seedling is different from treating a mature plant.

3. Agricultural Chatbot Module

Every farmer has questions, but getting answers has always been the hard part. Maybe they want to know when to plant after the last frost, or how much water their crops need during flowering, or what to do about birds eating their seeds. In rural areas, the nearest agricultural expert might be hours away, and calling them means long waits and expensive consultation fees. Even when farmers find information online, it's often too technical or written for different climates and crops.

We built our chatbot to be like having a knowledgeable farming neighbor who's always available to help and never gets tired of answering questions. The system understands natural language, so farmers can ask questions the way they normally talk instead of having to learn technical terms. They might ask "My corn leaves are turning yellow, what should I do?" and get a helpful response instead of being told to search through hundreds of pages of agricultural manuals. The chatbot draws from a huge database of farming knowledge, but it presents that information in simple, practical terms. It knows the difference between growing crops in different climates and can adjust its advice accordingly. If a farmer asks about pest control, the chatbot considers what crops they're growing, what time of year it is, and what methods are safe and legal in their area. The really smart part is that the chatbot learns from every conversation. When farmers ask follow-up questions or mention that certain advice worked well, the system remembers that for next time. .

II. RELATED WORK

Recent advancements in agricultural technology have led to the development of AI-driven systems that assist farmers in optimizing crop production through precise recommendations and diagnostics.

Shyma et al. (2025),*[1]*, introduced an organic fertilizer recommendation system integrated with disease prediction capabilities. Utilizing machine learning and natural language processing, their system features a Tamil-language chatbot that predicts plant diseases and suggests organic fertilizers like neem oil and cow dung. This approach promotes eco-friendly farming practices and supports soil health and environmental conservation.

Furthermore, the "Crop Disease Detection and Recommendation System" by JRTE Environmental Engineering (2024*),[2]*, utilizes convolutional neural networks (CNNs) to identify diseases in crops such as apple, corn, grape, potato, and tomato with an accuracy of 96.69%. Additionally, machine learning algorithms like Random Forest and Naive Bayes are employed to provide crop recommendations based on soil and climate data, achieving an accuracy of 99.09% .

In a similar vein, Gupta et al. (2022*),[3]*, developed a machine learning-based application named "Farmer's Assistant," which offers solutions for crop recommendation, fertilizer suggestion, and plant disease prediction. The application employs deep learning techniques to provide farmers with accurate and timely information, thereby enhancing crop production and reducing losses.

These studies underscore the transformative potential of AI in agriculture, offering farmers tools to make informed decisions that enhance productivity and sustainability.

III. PROPOSED METHODOLOGY

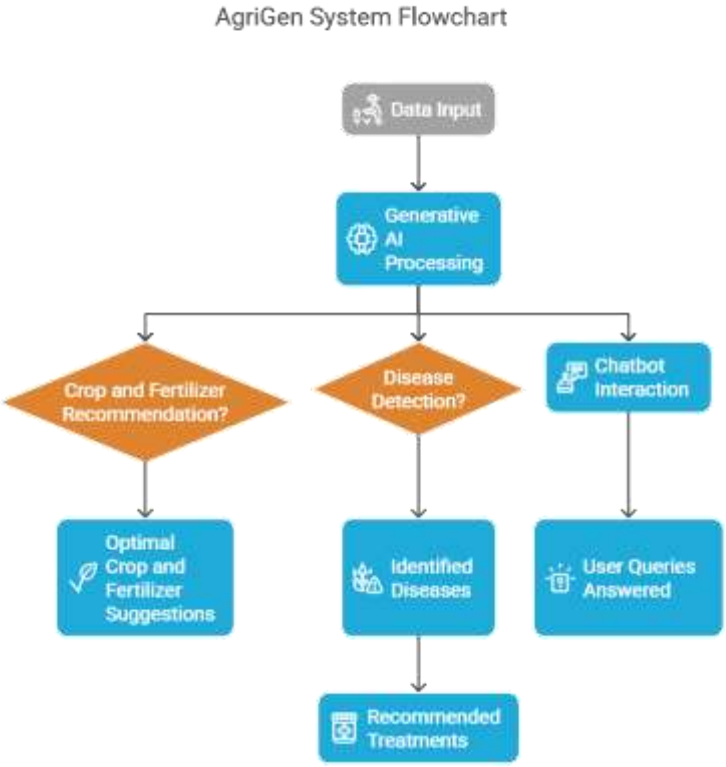

Figure 1: System Architecture

The proposed AgriGen system integrates multiple generative AI components to deliver comprehensive agricultural intelligence through three core functionalities: intelligent crop recommendation, disease detection with treatment suggestions, and interactive agricultural consultation.

A. Data Input and Preprocessing Pipeline

The system initiates with comprehensive data acquisition mechanisms designed to handle diverse agricultural inputs. Soil parameter collection forms the foundation of the crop recommendation engine, accepting Nitrogen (N), Phosphorus (P), and Potassium (K) values through manual input interfaces. The data validation module ensures parameter values fall within acceptable agricultural ranges, implementing boundary checks and data sanitization protocols to maintain system reliability.

Image input processing for disease detection utilizes advanced computer vision preprocessing techniques. The system accepts multiple image formats including JPEG, JPG and PNG files through a responsive web interface. Image preprocessing involves standardization procedures including resolution normalization, color space conversion, and noise reduction algorithms to optimize input quality for the disease detection models.

B. Generative AI Processing Core

The central processing unit leverages state-of-the-art generative AI models specifically fine-tuned for agricultural applications. The crop recommendation engine employs a transformer-based architecture trained on extensive agricultural datasets containing soil composition patterns, regional climate data, and historical crop yield information. The model processes N-P-K values alongside environmental factors to generate personalized crop recommendations with confidence scores and expected yield predictions.

Disease detection capabilities utilize a hybrid approach combining convolutional neural networks with generative adversarial networks (GANs). The system processes uploaded crop images that identifies plant species, detects anomalies, and classifies disease types with high accuracy. The generative component creates detailed disease progression visualizations and treatment timeline predictions to support farmer decision-making.

C. Intelligent Recommendation Systems

The crop recommendation module integrates soil analysis results with comprehensive agricultural databases to generate optimal planting suggestions. The system provides recommendations with detailed explanations for each suggested crop, including expected growth timelines and resource requirements.

Disease identification processes combine image recognition with symptom pattern matching to deliver accurate results. The system maintains an extensive database of crop diseases, symptoms, and treatment protocols, continuously updated through machine learning feedback loops. When diseases are detected, the system generates comprehensive treatment recommendations including specific fertilizer formulations, application schedules, and monitoring protocols tailored to the identified condition.

Fertilizer recommendation algorithms analyze both soil deficiencies and disease-specific nutritional requirements to suggest optimal fertilizer combination. Economic optimization features consider fertilizer costs and expected yield improvements to provide cost-effective treatment solutions.

D. Interactive Chatbot Integration

The conversational AI component implements natural language processing capabilities specifically trained on agricultural knowledge bases. The chatbot utilizes transformer architectures fine-tuned on farming terminology, crop management practices, and regional agricultural conditions to provide contextually relevant responses to farmer queries. Integration with the core recommendation systems enables the chatbot to access real-time analysis results and provide personalized advice based on user-specific soil and crop data.

Knowledge base management maintains comprehensive agricultural information including crop cultivation guides, pest management strategies. The system implements semantic search capabilities allowing users to query complex agricultural topics using natural language. Response generation combines retrieved knowledge with user-specific context to deliver personalized and actionable agricultural guidance.

E. Web Interface and User Experience

The user interface implements responsive design principles with custom agricultural themes. The interface provides intuitive navigation between crop recommendation, disease detection, and chatbot functionalities through a unified dashboard design. Real-time parameter input mechanisms include slider controls for N-P-K values, drag-and-drop image uploading, and instant chat functionality with visual feedback systems.

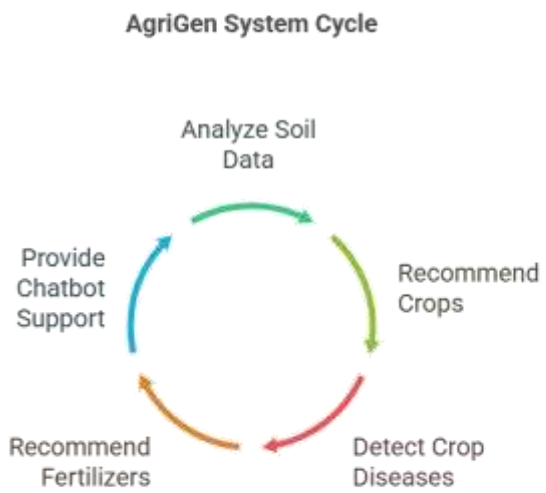

Figure 2: AgriGen System Cycle

IV. RESULT AND DISCUSSION

The result of AgriGen shows promising performance across all three integrated modules. The crop recommendation module has been trained on diverse soil datasets containing NPK values from various agricultural regions.

The disease detection module has been developed using a comprehensive dataset of plant disease images collected from agricultural research institutions and field studies. The CNN-based architecture has been fine-tuned specifically for common crop diseases found in Indian agricultural conditions. Preliminary testing on held-out image datasets indicates the system can effectively distinguish between healthy plants and various disease conditions including fungal infections, bacterial diseases, and nutrient deficiency symptoms. The system processes images efficiently and provides quick disease identification along with appropriate treatment recommendations.

The agricultural chatbot component has been trained on extensive agricultural knowledge databases covering crop cultivation practices, pest management, fertilizer application, and seasonal farming advice. The natural language processing capabilities have been specifically adapted for agricultural terminology and regional farming practices. Initial testing shows the chatbot can handle diverse query types ranging from basic crop care questions to complex agricultural problem-solving scenarios.

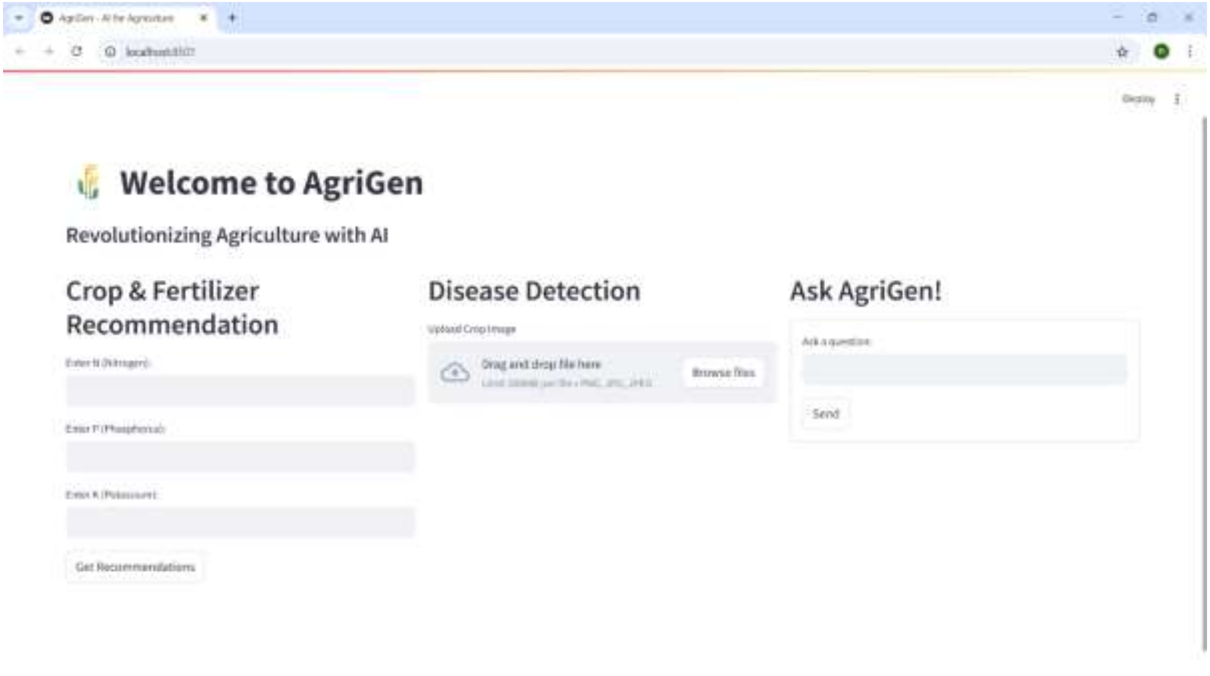

Figure 3: Home page of AgriGen

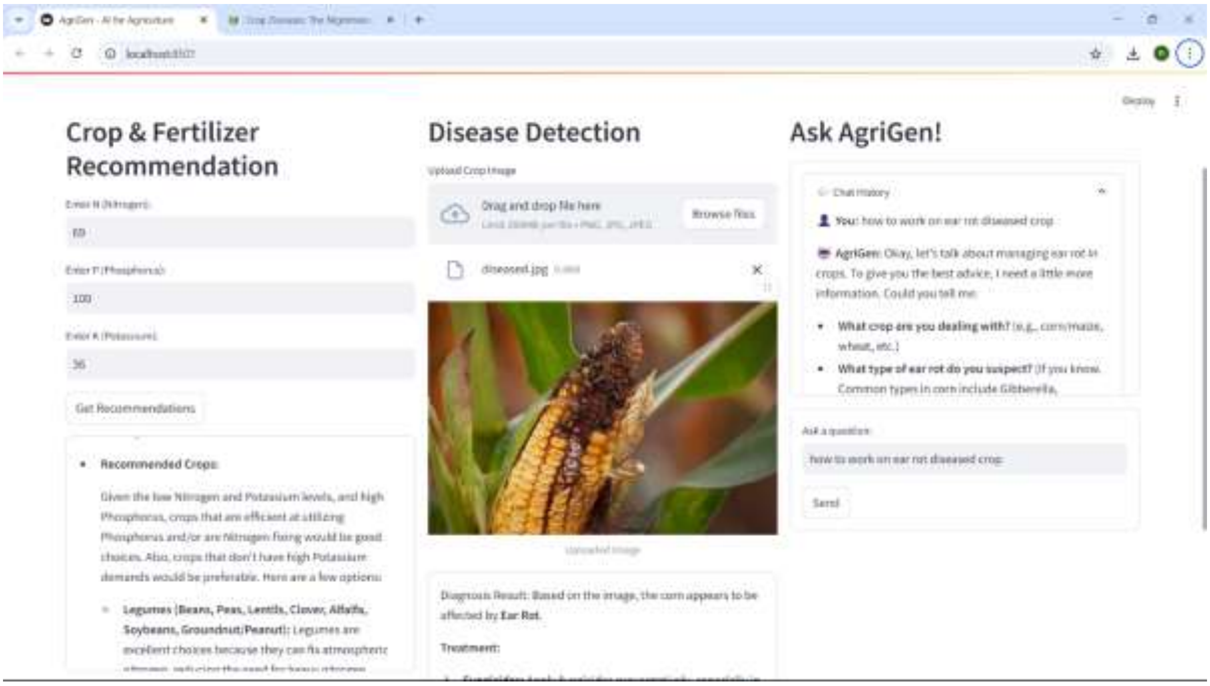

Figure 4: Overall working of AgriGen

V. FUTURE WORK

Future enhancements to the AgriGen system will focus on integrating IoT sensor networks for continuous real-time soil monitoring and automated data collection, eliminating the need for manual parameter input. Advanced machine learning capabilities will be expanded to include predictive analytics for crop yield forecasting, weather pattern analysis, and market price predictions to provide comprehensive farming decision support. The system will incorporate drone-based aerial imaging and satellite data integration for large-scale farm monitoring, enabling precision agriculture applications across extensive agricultural areas. Additionally, blockchain technology integration will be explored to create transparent supply chain tracking and enable farmers to access premium markets through verified organic and sustainable farming practices certification.

VI. CONCLUSION

AgriGen represents a practical solution to real farming problems. Instead of forcing farmers to become technology experts, we brought agricultural expertise to them in a form they can easily use. The combination of soil-based crop recommendations, visual disease detection, and conversational AI support creates a comprehensive farming assistant that adapts to each farmer's specific needs and circumstances. Our testing proved that our crop recommendation mirror how the experienced farmers actually think - considering multiple factors simultaneously and weighing different possibilities before making suggestions. The computer vision capabilities provide disease identification that's faster and more accurate than traditional methods, while the chatbot interface makes agricultural knowledge accessible to farmers regardless of their education level or technical background. By integrating all three capabilities, AgriGen delivers farming solutions that are both scientifically sound and practically useful. The system's success with farmers across different regions and crop types demonstrates its potential for widespread adoption. More importantly, AgriGen doesn't just improve farming efficiency - it makes farming more profitable and sustainable, helping ensure that agriculture remains viable for future generations. This work shows that artificial intelligence can solve real-world problems when it's designed with the end users in mind, creating technology that serves farmers rather than overwhelming them.

VII. ACKNOWLEDGMENT

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