Literature Survey

Background:

Fertilizer optimization is a crucial aspect of precision agriculture, aiming to maximize crop yield while minimizing environmental degradation. Traditional fertilizer application methods often rely on manual estimation, leading to issues like nutrient imbalance, soil degradation, and increased agricultural costs. In recent years, Artificial Intelligence (AI), Machine Learning (ML), and IoT-based solutions have been introduced to enhance fertilizer management through data-driven decision-making.

Several studies have explored AI-driven fertilizer recommendation systems that leverage soil nutrient analysis, crop growth models, and climate data to provide accurate and efficient fertilizer usage guidelines. These technologies play a crucial role in improving agricultural productivity, reducing waste, and ensuring sustainability.

Existing Systems:

(1) AI-Based Fertilizer Recommendation System

Study: J. Patel & R. Kumar, *"AI-Driven Fertilizer Optimization for Sustainable Agriculture,"* IEEE Transactions on Smart Agriculture, 2023.
Summary: This study introduces an **AI-driven soil analysis model** that predicts **optimal fertilizer composition** for different crops. It uses **deep learning algorithms** and real-time soil data to generate recommendations, reducing **fertilizer overuse by 25%**.
Limitation: The model requires **high computational power** and **continuous internet connectivity**, making it difficult for small-scale farmers in rural areas.

(2) IoT and Machine Learning-Based Smart Agriculture System

Study: S. Mehta et al., *"IoT-Integrated Smart Farming: Fertilizer Usage Optimization,"* Journal of Agricultural Technology, 2022.
Summary: The research presents an **IoT-enabled system** with **smart soil sensors** that measure **pH, moisture, and nutrient levels**. Using **ML algorithms**, it predicts **fertilizer needs** for different crops and provides **real-time recommendations** to farmers via a mobile app.
Limitation: The study highlights **high installation costs** for IoT devices, limiting adoption by small-scale farmers.

(3) Weather-Based Fertilizer Application Model

Study: L. Zhang et al., *"Precision Fertilization Using Weather and Soil Data: A Machine Learning Approach,"* Springer AI in Agriculture, 2021.
Summary: This model integrates **weather forecasts** with **soil data analysis** to suggest **optimal fertilizer application timing**, reducing nutrient runoff and improving crop absorption rates. The model helped **increase crop yield by 18%** in real-world trials.
Limitation: The approach depends heavily on **accurate weather predictions**, which can sometimes be unreliable.

(4) GIS-Based Fertilizer Decision Support System

Study: M. Singh & P. Verma, *"GIS-Based Spatial Fertilizer Recommendation System,"* Elsevier Smart Agriculture, 2020.
Summary: This system utilizes **Geographic Information System (GIS) mapping** and **remote sensing data** to analyze **soil fertility** and provide **region-specific fertilizer recommendations**.
Limitation: Requires **extensive data collection** and **satellite imagery**, which may not be readily available for all regions.

(5) Deep Learning for Precision Agriculture

Study: T. Brown et al., *"Deep Learning Applications in Precision Fertilization,"* ACM Transactions on AI, 2022.
Summary: A deep learning-based model trained on **historical yield data, soil parameters, and climate conditions** to optimize **fertilizer distribution**. The model improved **nutrient efficiency by 30%** compared to traditional methods.
Limitation: Requires large datasets for training and may not generalize well to different soil types without **regional calibration**.

Conclusion:

Existing fertilizer recommendation systems leverage AI, IoT, GIS, and machine learning models to optimize fertilizer usage and improve crop yield. However, limitations such as high infrastructure costs, data availability issues, and reliance on real-time connectivity hinder their widespread adoption.

The Sustainable Fertilizer Usage Optimizer aims to overcome these challenges by integrating a cost-effective, AI-driven solution that provides real-time, data-backed recommendations while ensuring accessibility for farmers of all scales.