EAST WEST UNIVERSITY

Department of Computer Science and Engineering

Capstone Project Report

CSE400A

Crop Selection Prediction Method for Soybean, Sesame, Sunflower and Mustard Based on Soil properties

Supervised By

Dr. Mohammad Salah Uddin

Associate Professor, Department of Computer Science and Engineering

East West University

Submitted By

Name	ID
Ahsanul Hoque	2019-2-60-008
Kazi Jihan Hasan	2020-1-60-034
Mohd. Riyaj-Us-Salehin	2020-1-60-148
Farhan Asfar	2020-1-60-154

Date of Submission

July 6, 2023

Table of Contents

ABSTRACT 4

1. Background 5

2. Related Works 7

3. Research Questions 9

4. Objectives 9

5. Planned Methodology 10

5.1 Data Collection **11**

5.2 Crop Data Acquisition **11**

5.3 Data Preprocessing **12**

5.4 Dataset Description of Crop Dataset **13**

6. Data Analysis Plan 15

7. Expected Result 16

8. Soil Component Calculation Metrics 17

9. Crops Analysis 20

9.1 Soybean **20**

Soybean Varieties: 20

Season for Plantation: 21

Where to Plant: 21

Temperature to Grow Soybeans: 22

Nutrients Requirements: 22

Life Cycle: 22

Companion Plants: 23

Soybean Diseases: 23

9.2 Sesame **23**

Sesame Varieties: 24

Climate Condition: 24

Soil Requirement: 24

Manures and Fertilizers in Sesame Farming: 25

Companion Plants: 25

9.3 Sunflower **26**

1. Tall sunflowers 26

2. Dwarf sunflowers 27

3. Florist sunflowers 28

4. Branching sunflowers 29

5. Perennial sunflowers 30

What's The Best Soil for Sunflowers?....................30
What is Loam Soil? 31
How Deep Should the Soil be for Sunflowers?....................31
Should One Fertilize Sunflowers - and how?....................31
Composted Manure....................31
Fertilizer....................32
How Often Should One Water Sunflowers?....................32
Are Sunflowers Good for the Soil? 32
Crop Rotation 33
Phytoremediation....................33
9.4 **Mustard.................... 34**
Some HYV of mustard:....................34
Suitable conditions to grow mustard 35
Measures and Fertilizers 35
10. References....................36

ABSTRACT

To maximize crop yield and effective agriculture practices, accurate assessment of soil components is very crucial. This study aims to develop a method for detecting soil components using NPK soil sensors and predicting suitable crops to cultivate using a machine learning model. The NPK soil sensor is a cutting-edge device with probes that measures the levels of nitrogen(N), phosphorus(P), and potassium(K), which are the key indicators of soil fertility.

Since most of the soil analysis is performed in the laboratory, this project proposes to develop a fast and simple analytical tool. Our proposed methodology involves collecting soil samples from different agricultural regions and analyzing the soil components using soil sensors. We will be developing a predictive model by correlating the sensor data with the known crop requirements and agronomic knowledge which will recommend suitable crops for a specific soil type.

The real-time data from the sensors will help to decrease the negative impact of chemicals on the environment without the reduction of crop yield and the proposed approach has a short measurement duration for real-time data analysis.

1. Background

Effective agriculture practices and accurate assessment of soil components is essential for the growth of crop and tuned fertilization. However, achieving optimal crop production depends on the fertility and composition of the soil in which the crops are cultivated.

Traditionally, farmers have relied on the laboratory analysis for soil testing methods to determine the nutrient levels and fertility. But this method is time-consuming and it requires special expertise for analyzing the data.

Getting real time data and making immediate decision is not possible in these methods. As a result, farmers cannot assess soil components and select suitable crops for cultivation.

To address these challenges, effective and advanced sensors have emerged which offer potential solutions for quick and on-the-spot soil assessment. NPK soil sensor is a portable device which can measure the concentration of nitrogen, phosphorus, and potassium in real-time. It can provide the immediate insights of the soil's nutrient compositions.

The NPK soil sensor uses different measurement techniques, such as spectroscopy or iron-selective electrodes to quantify the levels of nitrogen, phosphorus, and potassium in the soil. Using this soil sensor, it is possible to predict suitability of a specific soil type for different crops by integrating the measurements with agronomic knowledge and crop requirements.

Developing a reliable method for detecting soil components and predicting which crop will suit in that soil based on the soil components using the NPK soil sensor holds a significant potential for precision agriculture. Farmers can make efficient use of the resources, minimize fertilizer waste and reduce environmental impacts by accurately assessing the nutrient composition of the soil and recommending appropriate crops for that soil. Moreover, the use of this sensor can empower the farmers by enabling them to adapt cultivation strategies to specific soil condition and they can take more data-driven decision to ultimately enhance the overall agriculture productivity.

In this study, we will be collecting soil samples from different agriculture regions and measure the nutrient composition and which crops are being cultivated in those soils. It will enable us to create a data set with nutrient features and other components of soil. By correlating the data set with agronomic knowledge, we can then train the data set with different machine learning models and find which one fits the best. Thus, we will be able to develop a reliable model to use the NPK soil sensor to get real time data, analyzing them and predicting suitable crops to cultivate. The findings of this project can contribute to the advancement of precision agriculture and sustainable farming practices benefiting farmers and the global food yielding system.

2. Related Works

Crop selection prediction is an important task for optimizing crop production and ensuring food security. It involves choosing the most suitable crops for cultivation based on various factors such as soil properties, environmental conditions, and management practices. Several methods have been proposed in the literature to address this problem using different techniques such as machine learning, optimization, and crop modeling.

Machine learning methods use data-driven approaches to learn patterns and relationships from historical data and make predictions for new scenarios. For example, Suruliandi et al. [1] conducted a comparative study of various wrapper ***feature selection methods*** for crop prediction using classification techniques. They suggested the most suitable crops for land based on soil and environmental characteristics. They found that the Recursive Feature Elimination technique with the Adaptive Bagging classifier outperformed the others. Ansarifar et al. [2] proposed an ***interaction regression model*** for crop yield prediction that integrated optimization, machine learning, and agronomic insight. They achieved a high prediction accuracy and identified several environments by management interactions for corn and soybean yield. They also quantified the contributions of weather, soil, management, and their interactions to crop yield. Rajesh et al. [3] applied machine learning techniques such as ***k-means clustering, decision tree, and random fores***t to predict the optimal crop based on soil parameters. They compared the performance of the models and concluded that random forest was the best.

Optimization methods use mathematical models and algorithms to find the optimal solutions for crop selection problems. They often incorporate constraints and objectives that reflect the preferences and goals of the decision makers. For example, Wang et al. [4] developed ***a multi-objective optimization model for crop*** planning that maximized the total profit and minimized the total water consumption. They used a genetic algorithm to solve the model and applied it to a case study in China. They analyzed the trade-offs between the objectives and provided insights for water-saving strategies. Kumar et al. [5] formulated ***a linear programming model for crop selection*** that maximized the net return subject to resource availability and crop rotation constraints. They solved the model using LINGO software and applied it to a case study in India. They evaluated the impact of different scenarios on the optimal crop plan and suggested policy implications.

Crop models are mechanistic or empirical models that simulate the growth and development of crops under different conditions. They often capture the complex interactions among genotype, environment, and management factors that affect crop performance. For example, Archontoulis et al. [6] used a ***process-based crop model (APSIM)*** to predict corn and soybean yields at various locations in Iowa, USA. They calibrated and validated the model using field data and evaluated its accuracy and uncertainty. They also explored the effects of different management practices on yield variability and stability. Li et al. [7] used an ***empirical crop model*** (EPIC) to predict winter wheat yields at different sites in China. They calibrated and validated the model using field data and remote sensing data. They also assessed the impacts of climate change and adaptation measures on yield potential.

3. Research Questions

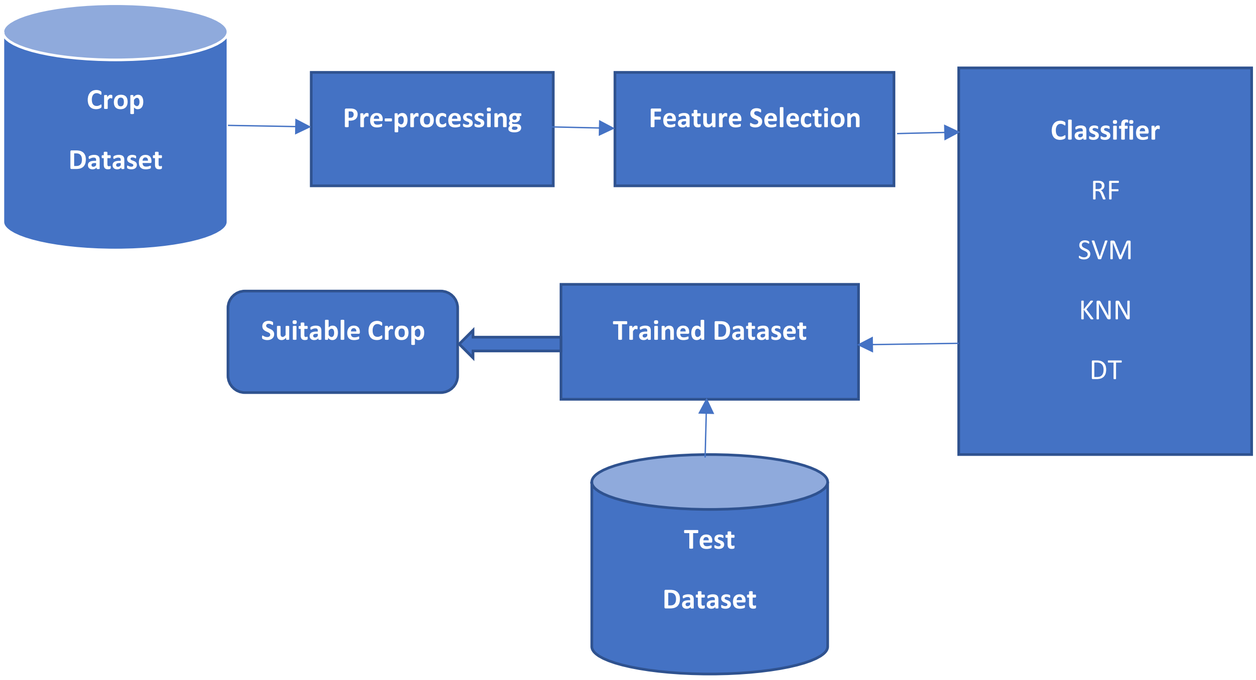
- How NPK soil sensor collect data from soil?
- How to analyze the data to predict the soil's nature?
- What features of soil nutrients have been considered to generate the dataset?
- How this model will predict the suitable crops for a specific type of soil?

4. Objectives

- Developing user friendly UI and precise analytical tool to analyze soil components.
- Reducing the measurement duration of soil nutrients.
- Assisting farmers and agriculture officers to take effective decisions based on the soil nature.
- Developing a model which will predict which crop to cultivate in a specific type of soil.

5. Planned Methodology

Predicting suitable crops for a specific type of soil includes data collection, crop data acquisition, data preprocessing, feature selection, model development, model evaluation, and finally crop selection prediction.



5.1 Data Collection

- As we have specified the crops we will be predicting, we are going to target regions which are known for cultivating soybean, sesame, sunflower, and mustard. The soil characteristics and climate conditions of these targeted areas will be taken in consideration. Different features like pH (potential of Hydrogen), EC (electrical conductivity), Nitrogen, Phosphorus, Potassium, Rainfall, Temperature will be incorporated in the dataset.

5.2 Crop Data Acquisition

Crop data acquisition includes field surveys, visiting agricultural research institutions, exploring agricultural databases.

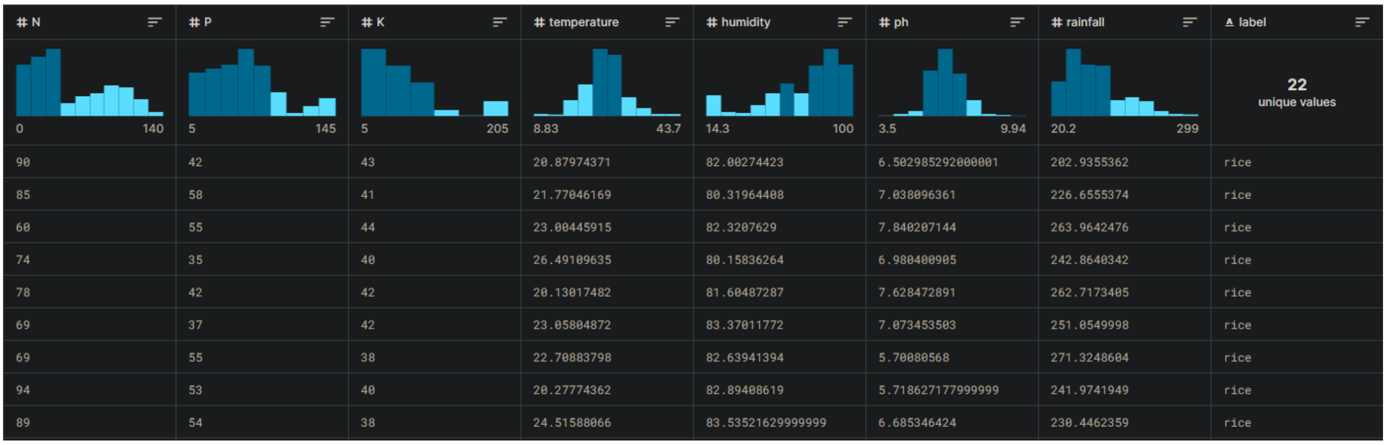
- **Field Survey:** We will conduct field surveys and interview local farmers, agricultural extension officers, and agronomists to gather crop-specific information including crop growth patterns, yield, quality parameters, and phenology [8].
- **Visiting Research Institutes:** We will be visiting **Soil Resource Development Institute** to collect studies on soybean, sesame, sunflower, and mustard crops. We will gather information about how they collect data from soil and analyze them in the lab.
- **Agricultural Databases:** For further clarity and finding different features and parameters we will be exploring available datasets for soil prediction and crop analysis.

5.3 Data Preprocessing

Data preprocessing involves cleaning, transforming, and organizing the data to ensure its compatibility with the machine learning models.

- **Data Cleaning:** Missing values should be identified and handled using median imputation, or regression imputation. Also, incomplete data should be excluded for more accurate results.
- **Data Integration:** For multiple data sources, the data should be integrated into a single dataset ensuring that the variables are aligned and inconsistencies are handled.
- **Feature Selection:** We need to identify relevant features which are important soil and crop properties.
- **Data Splitting:** We will divide the preprocessed dataset into training subsets and testing subset. The training subsets will be used to build and train the predictive model and the testing subset will be used for model evaluation and validation.

Dataset Preview



# N	# P	# K	# temperature	# humidity	# ph	# rainfall	label
0 140	5 145	5 205	8.83 43.7	14.3 100	3.5 9.94	20.2 299	22 unique values
90	42	43	20.87974371	82.00274423	6.502985292000001	202.9355362	rice
85	58	41	21.77046169	80.31964408	7.038096361	226.6555374	rice
60	55	44	23.00445915	82.3207629	7.840207144	263.9642476	rice
74	35	40	26.49109635	80.15836264	6.980400905	242.8640342	rice
78	42	42	20.13017482	81.60487287	7.628472891	262.7173405	rice
69	37	42	23.05804872	83.37011772	7.073453503	251.0549998	rice
69	55	38	22.70883798	82.63941394	5.70080568	271.3248604	rice
94	53	40	20.27774362	82.89408619	5.718627177999999	241.9741949	rice
89	54	38	24.51588066	83.53521629999999	6.685346424	230.4462359	rice

Crop Prediction Dataset

5.4 Dataset Description of Crop Dataset

Features	Type	Description
pH (potential of Hydrogen)	Numeric	pH is the main factor for farming
EC (Electrical Conductivity)	Numeric	It affects crop productivity
N (Nitrogen)	Numeric	It helps transfer energy from sunlight to plants
P (Phosphorus)	Numeric	Stimulates early plan growth, and hastens maturity
K (Potassium)	Numeric	Increases vigor and disease resistance of plants, helps form starches, and sugars
Temperature	Numeric	Important for growth and development
Rainfall	Numeric	Rainfall has great impact on crop growth. Excessive and insufficient rainfall affects crop yield

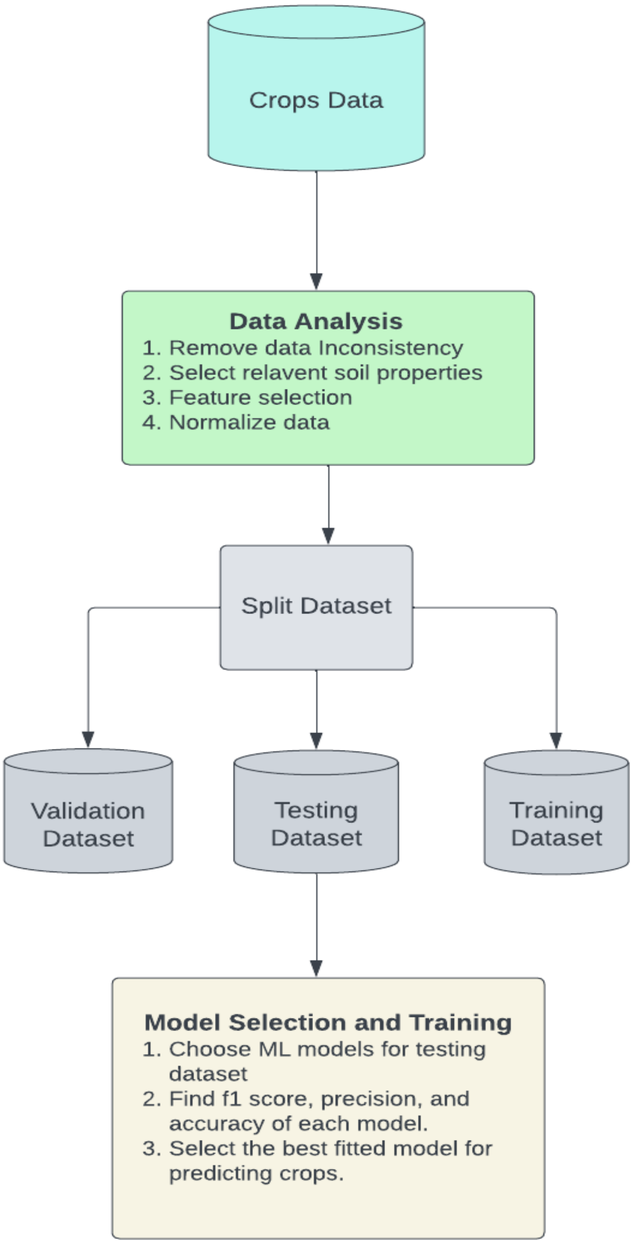
Crop Dataset Description [9]

PERFORMANCE METRICS DESCRIPTION

Metric	Formula	Range	Description
P	$\frac{TP}{TP+FP}$	0 to 1. Value nearby 1 denotes has less false positive prediction	The number of true positive predictions divided by the total number of positive predictions is determined as precision.
R	$\frac{TP}{TP+FN}$	0 to 1. Value close by 1 means has less false negative prediction	It is defined as the number of true positive predictions divided by the total number of all relevant samples.
S	$\frac{TN}{TN+FP}$	0 to 1. Value close to 1 indicates has less negative prediction	The proportion of negative results out of the number of samples which were actually negative.
F1 Score	$2 * \frac{PPV.TPR}{PPV+TPR}$	0 to 1. Value close 1 implies has better precision and recall; Value 0 means worst precision and recall	The accuracy of the measurement test and is known as the weighted harmonic mean of the tests' precision and recall. It also tries to find the balance between precision and recall.

6. Data Analysis Plan

The custom dataset for this research will be constructed using the dataset that will be collected through different research labs, crops field, and data available on cloud. The data collection process will include visiting research labs and local crop field. For predicting soybean, sesame, sunflower, and mustard we will consider the following features, pH metrics of the soil, percentage of nitrogen, phosphorus, and potassium, humidity, average temperature and rainfall.



7. Expected Result

The expected result of this research is to predict the suitable crops between soybean, sesame, sunflower, and mustard for a specific type of soil. The machine learning models will be used to find out which model fits the best and the model data and sensor data can be integrated in a device with a user interface which will help the user to identify the measurement of soil nutrients and find which crop will be fitted for the soil.

This system will help the farmers to know about their soil conditions within no time and it will increase the efficiency of farming. Certainly, it will also increase the crop yielding growth.

8. Soil Component Calculation Metrics

The formulas in more detail. Here are some explanations for each parameter:

- Soil pH: The pH is a measure of the acidity or alkalinity of the soil solution. It is defined as the negative logarithm of the hydrogen ion concentration [H+]. The Nernst equation relates the pH to the electrode potential E, which is measured by the glass electrode in the probe. The equation is:

$$E = E_0 + \frac{RT}{nF} \ln [H^+]$$

where E0 is the standard electrode potential, R is the gas constant, T is the temperature in kelvin, n is the number of electrons transferred (1 for hydrogen), and F is the Faraday constant. By rearranging the equation, we can get:

$$pH = -\frac{RT}{nF} \ln [H^+] = -\frac{E - E_0}{\frac{RT}{nF}}$$

The probe measures E and uses a known value of E0 to calculate ph.

- Soil NPK: The NPK are the three main macronutrients for plant growth. They are measured by using ion-selective electrodes that respond selectively to nitrate (NO3-), phosphate (PO43-), and potassium (K+) ions in the soil solution [10]. The electrodes also use the Nernst equation to relate the ion concentration to the electrode potential. The equation is:

$$E = E_0 + \frac{RT}{nF} \ln [X]$$

where X is the ion of interest (NO3-, PO43-, or K+). By rearranging the equation, we can get:

$$[X] = e^{\frac{nF}{RT}(E - E_0)}$$

The probe measures E and uses a known value of E0 to calculate [X]. However, since [X] is not directly proportional to NPK content, the probe also uses calibration curves that relate [X] to NPK content based on empirical data.

NPK content = [X] * K

where:

→NPK content is the concentration of nitrogen, potassium, or phosphorus in the soil, in milligrams per kilogram (mg/kg).

→[X] is the concentration of the ion of interest (NO3-, PO43-, or K+) in the soil solution, in moles per liter (mol/L).

→K is a calibration constant that is determined by the manufacturer of the NPK soil sensor.

- Soil temperature: The temperature is a measure of the average kinetic energy of the soil particles. It affects many physical and chemical processes in the soil, such as water evaporation, nutrient availability, microbial activity, etc. It is measured by using a thermistor that changes its resistance R according to the temperature T. The resistance is related to the temperature by using a formula such as:

$$R = R_0 e^{B(\frac{1}{T}-\frac{1}{T_0})}$$

where R0 is the resistance at a reference temperature T0, and B is a constant that depends on the thermistor material. By rearranging the equation, we can get:

$$T = \frac{BT_0}{B - T_0 \ln\left(\frac{R}{R_0}\right)}$$

The probe measures R and uses known values of R0, T0, and B to calculate T.

- Soil humidity: The humidity is a measure of the water content in the soil. It affects the soil porosity, permeability, aeration, etc. It is measured by using a capacitive sensor that changes its capacitance C according to the water content W. The capacitance is related to the water content by using a formula such as:

$$C = C_0 + kW$$

where C0 is the capacitance at zero water content, and k is a constant that depends on the soil type and sensor geometry. By rearranging the equation, we can get:

$$W = \frac{C - C_0}{k}$$

The probe measures C and uses known values of C0 and k to calculate W.

- Soil electrical conductivity (EC): The EC is a measure of how well the soil conducts electricity. It depends on the amount and type of dissolved salts in the soil solution. It affects the osmotic pressure, nutrient availability, plant growth, etc. It is measured by using a four-electrode method that applies an alternating current I between two electrodes and measures the voltage drop V between another two electrodes. The EC is related to the current and voltage by using Ohm's law:

$$V = IR$$

where R is the resistance of the soil solution. By rearranging the equation, we can get:

$$R = \frac{V}{I}$$

The EC is inversely proportional to R:

$$EC = \frac{1}{R} \times K$$

where K is a cell constant that depends on the geometry and spacing of the electrodes. The probe measures V and I and uses a known value of K to calculate EC [11].

9. Crops Analysis

To predict the suitable crop, we must know the characteristic of soil properties. In this section, we have analyzed in what condition soybean, sesame, sunflower, and mustard are yield.

9.1 Soybean

The soybean can be cultivated in most types of soil, but it thrives in warm, fertile, well-drained, sandy loam. Soybeans are usually harvested mechanically, after the leaves have fallen off the plant and the **moisture** content of the seed has dropped to 13 percent, permitting safe storage [11]. Like other legumes, the plant adds nitrogen to the soil by means of nitrogen-fixing bacteria and historically has been an important soil-enriching crop, though this practice is not common in most industrial agriculture systems.

Growing soybeans is not difficult. If you pay attention to the soil, sun, and temperature, you can grow soybeans.

Soybean Varieties:

- **Common name:** Soybean
- **Botanical name:** Glycine max
- **Origin:** East Asia

There are more than 10,000 soybean cultivars.

- Green-seed cultivars are considered the most tender and best flavored.
- Black-seeded beans are used for drying.
- Yellow-seed beans are used to make soy milk and flour.

Select a cultivar suited to your growing region; check with the nearby agricultural extension for recommendations.

Season for Plantation:

Soybean is a warm season crop to grow in summer. And loamy well drained fertile soil is good for growing soybeans. Low temperature affects crops severely.

The ideal temperature for soybean is 20-30℃.

For getting the optimal harvest one should follow these tips:

- Sow soybeans in spring 2 to 3 weeks after the average last frost date when the soil has warmed to at least 60°F (16°C).
- Soybeans can be planted earlier in warm-winter regions. Soybeans are not frost-tolerant.
- Soybeans grow best where the daytime temperature averages in the 70°F (21°C).

Where to Plant:

1. Plant soybeans in full sun—at least 8 hours of direct sun each day. If you plant soybeans in partial shade, you will not get the best yield.
2. Do not plant soybeans in cool or cold soil. Pre-warm the soil by placing black plastic over the planting bed for two to three weeks before planting. The black plastic will help draw solar heat into the soil. The soil needs to be at least 65°F/18°C for soybean seed germination.
3. Prepare the planting bed by adding plenty of aged compost to the soil. Before your first planting turn the aged compost 12 inches (30.4 cm) into the soil. In the following seasons, you can spread two inches of compost across the growing bed after each season and allow rain or irrigation to take the compost deep into the soil.
4. Soybeans prefer well-drained soil with plenty of organic matter and a pH of 6.5.
5. Plant soybeans in full sun; soybeans will tolerate partial shade but the yield will be reduced.
6. Soybeans grow best in loose, well-drained soil rich in organic matter.
7. Soybeans prefer a soil **pH of 6.0 to 6.8.**
8. Soybeans are tolerant of poor soil.

Temperature to Grow Soybeans:

- Soybeans require heat to produce well. (The soybean is native to tropical Asia.) There are varieties bred to grow in temperate zones, but not in cold regions.
- Soybean growth is optimal at temperatures between 68° and 77°F/20°C and 25°C. Temperatures between 53° to 68°F/12°C to 20°C are sufficient but germination, flowering, and pod development will be delayed. Temperatures greater than 86°F/30°C may hinder growth.
- For the best yield, choose a variety with the greatest number of days to maturity before the first killing frost.
- Warm weather and warm soil are required for the best yield. The soybean plant must make nearly all of its growth before it begins to bloom (blooming comes between 80 and 150 days after germination depending upon variety). Once the plant begins blooming and making seed pods, the plant stops growing up and out. Small plants at bloom time will not be large enough to yield well. (Optimal pod production per plant is about 50 pods—each with 2 or 3 oval-shaped beans.)

Nutrients Requirements:

- Add aged compost to planting beds in advance of planting.
- Side-dress soybeans with aged compost at midseason.
- Avoid adding **nitrogen**-rich fertilizers to planting beds. Soybeans, like other legumes, set up a mutual exchange with soil microorganisms called nitrogen-fixing bacteria to produce nitrogen compounds used by the plant.
- 12.5 kg per acre of **Nitrogen**
- 32 kg per acre of **Phosphorus**
- **Potassium** is required only if deficiency observed.

Life Cycle:

90-120 days from seed sowing to harvesting.

Companion Plants:

- Soybeans can be grown with potatoes, cucumbers, corn, strawberries, celery, and summer savory.
- Soybeans should not be planted with onion or garlic.

Soybean Diseases:

Soybeans are rarely attacked by a disease. Cultivators should rotate beans so that they do not grow in the same location more than every three years.

9.2 Sesame

Sesame (Sesamum indicum) is one of the oldest spices, dating from 1600 BC. Its exact origin is not yet known, but this is still to be determined after many DNA tests. However, it appears to originate in India, from where it subsequently spread to Africa and Asia. Sesame is an oily plant, as the seeds contain 55-60% oil and 24% protein. The cold extracted oil has a very refined taste, being used in the food industry, for confectionery and pastry.

The largest sesame areas are grown in Asia, especially in India, which holds about 2.5 million hectares, and in China, with 900,000 hectares. Other important sesame producers are Myanmar, Ethiopia, Nigeria, Tanzania and Sudan. However, the most productive sesame farms are located in Greece, where largest productions per hectare were recorded in 2013.

On the other hand, the largest sesame seeds importing countries are Japan, China, Turkey, South Korea and Israel [15].

Sesame Varieties:

Sesame seeds occur in many colors depending on the cultivar. The most traded variety of sesame is off-white colored. Other common colors are buff, tan, gold, brown, reddish, gray, and black.

Following are the hybrid varieties of sesame seeds:

CO-1, TMV-3, TMV-4, TMV-5, TMV-6, TMV-7, VRI(SV)-1, VRI(SV)-2, SVPR-1.

Climate Condition:

Sesame is a warm season annual crop grown in summer; drought tolerant. Sesame crop does not grow in frost conditions., Prolonged drought (or) heavy rains are not favorable conditions for its cultivation. Sesame crop is a tropical crop and this crop requires hot conditions during its growth period for best yield. Ideal temperature for sesame cultivation is between 25 °C – 30
°C. Extreme low and very high temperatures affect the growth.

Soil Requirement:

Sesame thrives well on soils with neutral reaction (or) slightly acidic type. There should not be any water stagnation in the soil, so make sure soil is well drained and light loamy soil for better growth performance. The preferred soil **pH range** of sesame crop is 5.5 to 8.0.

Saline soils or too much sandy soils are not suitable for sesame cultivation. Adding well rotten Farm Yard Manure to the soil is beneficial in getting higher yields[16].

Manures and Fertilizers in Sesame Farming:

Add 5 to 6 tons of Farm Yard Manure (F.M.Y) or well rotten compost at the time of soil preparation.

Fertilizers for rainfed and irrigated conditions are as follows:

Rainfed Crop:

- **Nitrogen** 40 kg/hectare
- **Phosphorus** 60 kg/hectare (30 to 35 days after sowing)
- **Potassium** 40 kg/hectare

Irrigated Crop:

- **Nitrogen** 60 kg/hectare
- **Phosphorus** 61 kg/hectare (30 to 35 days after sowing)
- **Potassium** 40 kg/hectare.

Companion Plants:

- Leguminous plants, such as beans, peas, or lentils, can be good companions for sesame. Legumes have the ability to fix nitrogen from the air into the soil, which can improve soil fertility and benefit sesame plants.
- Cucurbits like cucumber, squash, and melons can be compatible with sesame. Sesame provides a light shade that helps keep the soil moist and cool for cucurbits, while the cucurbits' sprawling vines can provide shade to the sesame plants.
- Certain herbs can act as companion plants for sesame. Basil, for example, can repel pests like aphids and mosquitoes, which can benefit the sesame crop. Other herbs like dill, coriander, or parsley can attract beneficial insects that help control pests.

9.3 Sunflower

There are more than 70 different varieties of sunflowers, but they can be categorized into five broad categories:

1: Tall Sunflowers

2: Dwarf Sunflowers

3: Florist Sunflowers

4: Branching Sunflowers

5: Perennial Sunflowers.

1. Tall sunflowers

Tall sunflowers (or even giant sunflowers) are very popular at home gardens. When you think of bright towering sunflowers, you are probably envisioning this category of sunflowers. Tall varieties can grow up to 16 ft (5m) tall!

Some of the most popular specific tall sunflower varieties include:

- **Skyscraper Sunflower** – This variety's seed heads will reach around 14-16 feet in height, making it an excellent choice if you have limited space in your garden.
- **Mammoth Sunflower** – These huge sunflowers grow to about 12 feet and are popular pollinators for bees and butterflies. Birds and squirrels also love eating their seeds as they fall to the ground.
- **Pike's Peak Sunflower** – This is the type of sunflower that other sunflowers look up to because it has the largest seeds! The seeds are 1 and a half inches long, producing extra tall plants that range from 12 to 15 feet.
- **American Giant Sunflower** – This type of sunflower is often used in growing competitions because it can grow so tall. Many have grown up to 15 feet tall with flowers 1 foot in diameter. The stems are extremely sturdy to support the giant flower.

  Larger sunflowers grow to be anywhere from 10 to 15 feet. The leaves of these tall plants can spread out quite far so make sure you've got quite a bit of room before planting these beauties in your garden.

2. Dwarf sunflowers

Dwarf sunflowers are a great choice for children’s gardens and for anyone who wants to grow stunning flowers but does not have the space for a full-sized variety. These plants can grow to only 1 to 3 feet tall! Many sunflowers of this type grow well in pots and some can even grow in window boxes.

The most common dwarf varieties include:

- **Teddy Bear Sunflower** – This variety has a fuzzy appearance (hence the Teddy name) and doesn’t grow taller than 3 feet. It is a member of the Helianthus Annuus family.
- **Syntactic Sunflower** – This dwarf sunflower produces no pollen, but blooms 1 to 3 times every year. Some plants can have as many as twenty flowers on it.
- **Big Smile Sunflower** – The petals on this sunflower appear very delicate and wide. They are beautiful in a children’s garden because of their height and attractive appearance.
- **Sunny Smile Sunflower** – This miniature sunflower is a great potted plant for porches, patios, and even your kitchen table. It flowers year-round and is a hybrid dwarf variation of the sunflower that does not produce pollen.

Dwarf sunflowers are perfect for small garden spaces as well as cutting gardens. They are also ideal if you want to grow lots of these beautiful flowers, but don’t have much room on your property. Because they’re so compact, many people like them in hanging baskets and planters that can be hung in larger areas like porches or patios (or even indoors).

3. Florist sunflowers

Florist sunflowers are specialty varieties bred for appearance and also not to produce pollen. Most florist sunflowers are single-stem varieties (each plant grows only one flower). Most florist sunflower varieties grow to be 5'-6' tall. The lack of pollen is a benefit for sunflowers in bouquets as the flowers won't dust homes and tabletops with yellow powdery pollen.

Here are two of the most popular lines of florist sunflowers:

- **Precut Sunflowers** – These flowers range from bright yellows to deep reds. There are even bi-color varieties available that look lovely. They are pollen-less and easy to grow.
- **Sun Rich Sunflowers** – This line of sunflowers is another top choice of florists as they are pollen-less and easy to grow.

While these flowers have been bred for the cut flower market, they make wonderful home garden plants as well. Get the whole family involved with planting these beauties and bringing them in for bouquets.

Branching sunflowers are unique in that each plant grows multiple flower heads (instead of just one big head each).

4. Branching sunflowers

This variety of sunflowers has a growth habit of producing many sides stems off of its main stem. Each stem has an individual flower, which allows the plant to bloom over a long period of time. Instead of just growing upward, these varieties grow outward as well. Most branching varieties grow about 5'-6' tall, but there are also a few dwarf varieties and a few taller varieties available.

Here are some of the most popular branching sunflowers to grow:

- **Lemon Queen Sunflower** – This heirloom sunflower has a beautiful pale lemon- yellow complexion with a chocolate brown center. This variety grows fast and tall and the seeds are enjoyed both by people and birds. Lemon Queen is known as the top sunflower for attracting bees and other beneficial pollinators.
- **Soraya Sunflower** – This annual sunflower has oblong leaves and extremely beautiful flowers. It branches in a way that makes the plant appear to have a ready-made bouquet.
- **Rouge Royal Sunflower** – This deep red sunflower grows to about 5 or 6 feet tall. It's a dramatic focal point in a garden and works well as an anchor plant for other foliage.

These beautiful branching varieties look lovely in a garden because they fill in space above smaller plants. They not only grow up but out, giving them more dimension.

5. Perennial sunflowers

While most garden sunflowers are annual (and must be planted each spring), there are a few species of sunflowers that are perennial plants. Perennial sunflowers live for many years and tend to have smaller flowers than the annual sunflowers described above. While the foliage dies back to the ground each fall, the roots of the plant live through wintertime and sprout again each spring.

- **Maximilian Sunflower (***Helianthus Maximilian)* – This species has a hairy stem and long, full petals. They produce flowers from late summer into fall. They love full sun and are deer-resistant.
- **Jerusalem Artichoke (***helianthus tuberoses)* – This species, also called sunchoke, is known for its edible tubers (roots) which are often prepared like potatoes.
- **Ashy Sunflower (***Helianthus mollies***)** – This species flowers from July to September and attracts lovely finches and other birds. It also thrives in sandy and gravelly soils.
- **Western Sunflower (***Helianthus occidentalis***)** – This species has small daisy-like sunflowers that appear in clusters above the plant, making it a favorite for pollinators.
- **Thin leaf Sunflower (***Helianthus decapetalus***)** – This species has daisy-like yellow flowers that tend to have 10 petal-like ray florets around the center.

These perennial sunflowers will grow back from their roots every year (meaning you don't have to re-plant them each spring).

What's The Best Soil for Sunflowers?

Sunflowers flourish when planted in a nutrient-rich, loam soil with a slightly acidic to alkaline pH of 6 to 7.5. Fertilizing sunflowers can promote growth, but is not essential for sunflowers in most soil conditions.

What is Loam Soil?

Loam soil is comprised of relatively equal parts of sand, silt, and clay. Capable of retaining nutrients and water, loam soil is ideal for gardening because it is permeable enough to provide adequate drainage. Plants like sunflowers thrive in loam soil because steadfast taproots can easily penetrate the silty, sandy texture.

How Deep Should the Soil be for Sunflowers?

Prepare the garden for sunflowers by tilling roughly 2-feet deep into loam soil. Because the sunflower's emerging taproot can easily penetrate loosed soil, tilling promotes initial growth for healthy plants. Taller varieties of sunflowers can produce a taproot that reaches 1-1/2 to 2 feet in length beneath the ground.

When the soil temperature reaches between 12.8°C and 15.6°C, it is the best time to sow sunflowers, typically mid-April through July Sunflower seeds should be planted directly into the ground, between 1 and 2 inches deep. Form rows between 2 and 3 feet apart.

Should One Fertilize Sunflowers - and how?

Providing a nutrient-rich soil will encourage sunflower growth, to produce robust stems, bountiful blooms, and hearty seeds. Because sunflowers grow rapidly, using fertilizer is recommended, especially for sandy, thin soils, and drier climates.

Agricultural research suggests that sunflowers are most susceptible to nitrogen levels and boron deficiency in the soil. Increased nitrogen levels in the soil can increase plant height and vegetation growth, but too much nitrogen could delay flowering and cause sunflowers to be more susceptible to disease. Low levels of boron result in hollowed seed formation.

Composted Manure

Composted manure, or animal feces, is an organic material used to increase the nutrient levels by slowly releasing valuable nitrogen, phosphorus, and potassium back into the soil. The composting process cleanses the manure of any potentially harmful parasites. Tilling composted manure into the ground also promotes water retention and aeration.

The nutrient level of the manure will vary slightly depending on animals' diets. Cow manure is commonly used because it has a sufficient supply of nitrogen, phosphorus, and potassium.

Chicken manure has the highest supply of nitrogen, phosphorus, and potassium compared to cow, horse, and goat manure because chickens have an extremely varied diet.

Fertilizer

Till fertilizer into the soil (8-inches deep) during planting time. Always follow the instructions provided.

Slow-release Milo granite provides a nitrogen supply for your sunflowers for up to 10-weeks when tilled into your soil.

How Often Should One Water Sunflowers?

One should provide sunflowers with approximately 2-gallons of water each week. Particularly in drier climates, it can be helpful to establish a daily watering routine to encourage young plants to grow. It is best to water sunflowers during either the early morning or late evening hours, to reduce the risk of evaporation.

If the garden climate gets rain several times throughout the week (1 to 1-1/2 inches).

Are Sunflowers Good for the Soil?

Growing sunflowers can not only help to enrich the soil between crops but can also be used as a method of restoring soil after contamination.

Crop Rotation

A popular choice of mid-western farmers to plant for agricultural crop rotation, sunflowers can help to prevent soil erosion, minimize weeds, and maintain nutrients and water in the soil between growing seasons.

Phytoremediation

Sunflowers are powerful soil healers because these plants can absorb and metabolize toxins from the soil. Environmental scientists have begun to plant sunflowers for *phytoremediation*, or the process of removing harmful metals, radioactive isotopes, and inorganics from soil and groundwater. Phytoremediation is a cost-effective, natural cleansing process.

Sunflowers used for phytoremediation cannot be grown for agricultural purposes. Instead, at the end of the sunflowers' lifespan, the plants must be harvested and discarded because they now contain harmful chemicals.

Now that you know the best soil conditions for sunflowers, you can be sure to keep these plants healthy and happy in your backyard.

9.4 Mustard

In Bangladesh, mustard is being grown for many years. It is mostly used for oil production. Mustard seed is in the third position all over the world according to its importance. But to earn foreign money from it, High Yielding Variants (HYV) must be produced and developed. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have developed many HYV of mustard to grow. Most of the HYV mustards produces about 40 to 50% oil from its seed. Most of the mustard seeds are being produced in Asian region. It is being highly produced in the American and European region also[19].

Some HYV of mustard:

HYV of mustards by BINA

Variety	Release Year	Crop Duration(days)	Potential Yield(t/ha)	Oil Content (%)
Safal	1991	90-95	2.2	43-44
Agran	1991	83-88	2.5	44
Bina Sarisha-3	1997	85-90	2.4	44
Bina Sarisha-4	1997	80-85	2.5	44
Bina Sarisha-5	2002	85-90	2.1	43
Bina Sarisha-6	2002	90-95	2.2	44
Bina Sarisha-7	2011	102-110	2.8	44
Bina Sarisha-8	2011	100-108	2.4	43

Source: (Bina.gov.bd)

Suitable conditions to grow mustard

The ideal temperature to grow mustard is 10 to 20 degrees Celsius. if temperature goes higher than 25 degrees Celsius than the production of mustard will go down. It is better to sow the seed between 2nd week of October to 2nd week of November.

Suitable soil pH for growing mustard is 5.5 to 6.8[20].

Measures and Fertilizers

12 to 15 tons of FYM per hector should be applied.

Nitrogen should be applied with the ammonium sulfide, so that the soil can get nitrogen and Sulphur together. For dry land it should be applied 30 to 60 kg/ha and in irrigated condition it should be 100 to 120 kg/ha. Phosphorus is also applied in form of single super phosphate (SSP). 20kg/ha for rainfed and 50kg/ha for irrigated crop.

Potassium is applied for the highly potassium deficient soils if needed, 20kg/ha.

Nitrogen is applied half on the time of sowing and the rest in the first irrigation. Potassium and phosphorus are applied at the time of sowing.

References

1. A. Suruliandi, G. Mariammal, S.P.Raja, Crop prediction based on soil and environmental characteristics using feature selection techniques, Mathematical and Computer Modelling of Dynamical Systems 27 (1) (2021) 117-140.
2. J.Ansarifar, L.Wang, S.V.Archontoulis, An interaction regression model for crop yield prediction, Scientific Reports 11 (2021) 17754.
3. K.Rajesh, S.Selvakumar, R.Saravanan, Crop prediction using machine learning, International Journal of Advanced Science and Technology 29 (7s) (2020) 3578-3586.
4. X.Wang, Y.Li, J.Huang, Z.Li, Multi-objective optimization model for crop planning: A case study in China, Computers and Electronics in Agriculture 136 (2017) 1-9.
5. R.Kumar, A.K.Singh, R.K.Singh, Linear programming approach for optimal crop planning: A case study of Uttar Pradesh state in India, Agricultural Economics Research Review 23 (2010) 129-136.
6. S.V.Archontoulis, M.A.Licht, E.Jintrawet, S.Kumudini, A systematic approach for testing APSIM simulations across locations, crops, and management systems, Agronomy Journal 110 (2) (2018) 537-554.
7. T.Li, J.Huang, Y.Wang, W.Li, Y.Liu, Z.Li, Winter wheat yield estimation based on the integration of the EPIC model and MODIS data, Agricultural and Forest Meteorology 263 (2018) 351-363.
8. Crop Recommendation Dataset | Kaggle.
9. G. Mariammal, A. Suruliandi, S. P. Raja and E. Poongothai, "Prediction of Land Suitability for Crop Cultivation Based on Soil and Environmental Characteristics Using Modified Recursive Feature Elimination Technique With Various Classifiers
10. L. Lvova and M. Nadporozhskaya, “Chemical sensors for soil analysis: principles and applications,” in *Elsevier eBooks*, 2017, pp. 637–678. doi: 10.1016/b978-0-12-804299-1.00018-7.
11. C. Jackisch *et al.*, “Soil moisture and matric potential – an open field comparison of sensor systems,” *Earth System Science Data*, vol. 12, no. 1, pp. 683–697, Mar. 2020, doi: 10.5194/essd-12-683-2020.
12. V. Cherlinka, “Soil Testing: How To Take Samples And Read Results,” *EOS Data Analytics*, Jun. 07, 2023. https://eos.com/blog/soil-testing/

13. L.. Lvova and M.. Nadporozhskaya, "Chemical sensors for soil analysis: principles and applications
14. How to Plant, Grow, and Harvest Soybeans - Harvest to Table
15. P. Aloi, “How to Grow and Care for Sesame Plants,” *The Spruce*, Feb. 2023, [Online]. Available: https://www.thespruce.com/growing-sesame-plants-5082982
16. Jagdish, “Sesame Farming (Gingelly) Information Guide | Agri Farming,” *Agri Farming*, Apr. 07, 2018. [Online]. Available: https://www.agrifarming.in/sesame-farming
17. S. Behera, “Step-by-Step Guide to Grow Black Cumin (Kalonji),” *krishijagran.com*, [Online]. Available: https://krishijagran.com/agripedia/step-by-step-guide-to-grow-black-cumin-kalonji/
18. “Fertilizing Sunflower,” *NDSU Agriculture*, Aug. 30, 2022. https://www.ndsu.edu/agriculture/extension/publications/fertilizing-sunflower
19. “Which Country Produces the Most Mustard Seeds?,” *Helgi Library*. https://www.helgilibrary.com/charts/which-country-produces-the-most-mustard-seeds
    P. G. Hiranmayee, “Mustard Cultivation Guide – Climate, Land Preparation, Varieties, Fertilisers, Sowing and Harvesting,” *krishijagran.com*, [Online]. Available: https://krishijagran.com/agripedia/mustard-cultivation-guide-climate-land-preparation-varieties-fertilisers-sowing-and-harvesting/
20. A Seminar Paper on Mustard Production in Bangladesh: Status, Opportunities and Challenges

    Yasir Arafat Reg. No.: 17-05-4461 MS student Term: Winter 2022 Department of Agricultural Extension and Rural Development BSMRAU