



## ARTI 401– Artificial Intelligence: Principles and techniques

Term 1 – 2023/2024

### Project Final Report

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- ✓ Title of the Project:

**PlantCare:** Intelligent Plant Health Diagnosis and Optimized System



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## **Abstract**

Farmers, gardeners, and plant enthusiasts often face problems due to a lack of continuous expert assistance, late detection of problems, inability to access solutions, and inefficient use of resources. To overcome these diagnostic obstacles, an efficient and user-friendly expert system with strong plant accuracy and detection capabilities and the ability to find AI-powered remedies is needed. This project purpose a **PlantCare** system using SW-Prolog software. The proposed system can provide a robust platform for identifying plants diseases, recognizing pests, assessing nutrient deficiencies, and evaluating environmental stressors. We created our own database by reviewing several papers and books to gain sufficient information. The dataset used consists of 48 plants with 10 diseases along with its treatments and recommendations. While the system has its limitations, based on several test cases and findings result, it can be concluded that the system has achieved faster, accurate and reliable diagnoses regarding the plant health results.

## **Chapter 1: Overview of the system**

### **1.1 introduction**

Introducing the Plant Health Diagnosis Expert System **PlantCare**. It is a powerful toolset designed to transform the way plant health assessment is done. Our ecosystem depends on plants, which provide essential resources and influence our overall quality of life. Keeping them healthy and productive, however, requires expertise in botany, pathology, agronomy, and other disciplines. With our Plant Health Diagnosis Expert System, innovative technologies and seasoned plant health professionals work together to provide quick, precise, and reliable diagnoses of plant health issues. By harnessing artificial intelligence, this system provides a robust platform for identifying diseases, recognizing pests, assessing nutrient deficiencies, and evaluating environmental stressors. Through our platform, users will be able to make well-informed decisions, optimize crop yields, and promote sustainable agricultural practices for a healthier and more prosperous future. On the other hand, agricultural experts and farmers will gain access to timely recommendations and personalized treatments. Let us secure our agricultural landscapes by leveraging the potential of technology and expertise.

### **1.2 Problem Statement**

Diagnostics of plant diseases, nutrient deficiencies, and environmental stressors remain a major challenge in traditional agricultural and horticultural practices. A common problem among farmers, gardeners, and plant enthusiasts is the lack of availability of expert assistance 24/7, the late detection of problems, the inability to access solutions, and the inefficiency of available resources. Additionally, an efficient and user-friendly expert system that has strong plant accuracy and detection capabilities and the capacity to find AI-powered remedies must be created in order to solve these diagnostic obstacles. With our expert system, you will be able to check the health of your plants and as well as receiving an accurate diagnosis and provide

recommendations. Moreover, the expert system will be supported by reliable scientific information, and through the process of user data entry into the program, diagnostic results for the user's plants will be displayed. By using the Prolog software, we will be able to Identify, formulate, and solve problems using artificial intelligence-based techniques that match the user's needs.

### **1.3 Motivation**

The challenges faced with traditional agricultural methods, such as the lack of professional assistance, the late discovery of plant health problems, and the wasteful use of resources, are what prompted the creation of the **PlantCare** system. The goal is to develop an effective and accessible expert system that utilizes the use of techniques based on AI to accurately identify and diagnose environmental stressors, nutrient deficiencies, and plant diseases. Furthermore, PlantCare aims to provide prompt and accurate diagnoses, customized recommendations, and educational resources to improve plant health and advance sustainable farming methods by utilizing AI and expert expertise. By utilizing technology and experience, this project aims to secure agricultural landscapes, increase agricultural output, and decrease crop losses.

### **1.3 Aim and Objectives**

#### **1.3.1 Aim**

The aim of a plant health diagnosis expert system is to develop a comprehensive and efficient tool that utilizes expert knowledge and computational algorithms to accurately diagnose and identify health issues and potential threats affecting plants. This system should provide timely and precise diagnoses, suggest appropriate treatments, and offer recommendations for preventative measures to maintain optimal plant health and productivity. The ultimate goal is to boost agricultural productivity, reduce crop losses, and promote sustainable farming practices.

#### **1.3.2 Project Objectives**

1. Develop an AI-robust database for accurate plant disease diagnosis to achieve a high accuracy rate in identifying plant diseases and issues based on user-entered data, validated through comparison with expert diagnoses.
2. Implement a recommendation system for personalized solutions to optimize plant health. Based on the system's findings, tailored recommendations will be generated to improve plant health and productivity by addressing plant diseases and nutrient deficiencies.
3. Create an educational component to increase user awareness and knowledge of plant diseases and care practices.

## **1.4 Limitation**

Despite its significant advancements in plant health diagnosis, **PlantCare** is not without limitations. As an evolving technology, Plantcare effectiveness is currently constrained by the availability of comprehensive data on plant diseases, pests, and nutrient deficiencies. While the system continuously learns and expands its knowledge base, it may encounter challenges in diagnosing rare or newly discovered plant health issues. We did not find a database for text to our idea, so we made our own database, and this took us a lot of time and effort. There is not enough information for the database. So, we reviewed several papers and searched many sites to get good and sufficient information. Application of ornamental or wild houseplants is less effective due to differences in plant diseases and environmental factors. We could not cover all plant types in our database, which is considered invalid and not reliable for every experienced system. We tried to cover some types of plants as much as possible, so we collected 10 diseases and explained and clarified them. Additionally, **PlantCare** performance is reliant on the quality of user-provided information, including images and descriptions of plant symptoms. Inaccurate or incomplete information may lead to misdiagnoses or inaccurate treatment recommendations. Furthermore, **PlantCare** is primarily designed for diagnosing plant health issues in common crops and agricultural settings. To overcome these limitations, continuous efforts are being made to enhance Plantcare knowledge base, improve its image recognition capabilities, and broaden its applicability to a wider range of plant species and environments. Collaborations with plant health experts, agricultural research institutions, and user feedback play a crucial role in refining the system's accuracy and expanding its scope.

## **1.5 Notations**

Abbreviation that has been used in the proposal.

#	Abbreviation	Definition
1	AI	Artificial Intelligence
2	CNN	Convolutional Neural Network
3	HTML	Hypertext Markup Language
4	KB	Knowledge Base
5	DL	Deep Learning
6	DB	Date Base
7	KBSee	knowledge-based system

**Table 1:** Notation Table

## Chapter 2: Literature Survey

The "Expert System to Diagnose Soil and Plant Types According to The Web-Based Forward Chaining Method" [1] represents a sophisticated computerized application designed with a specific purpose: to determine and categorize various soil and plant types effectively. This system is based on a methodology known as forward chaining, in which the system begins with available data and iteratively draws inferences. It is facilitated through a web-based platform, which allows for easy access, efficient processing, and seamless interaction. In this expert system, forward chaining involves a step-by-step progression through rules and facts. The web-based nature of the system allows users to input relevant data and observations, triggering the forward chaining process to initiate diagnosis and classification. With the help of cutting-edge technology, domain-specific knowledge, and intelligent reasoning, this expert system can identify soil and plant types with a high degree of precision.

Developing an Expert System to Diagnose Tomato Diseases [2] involves creating a sophisticated computer-based tool that leverages advanced algorithms and knowledge in agriculture, plant pathology, and artificial intelligence (AI) to accurately identify and diagnose diseases affecting tomato plants. The goal is to provide timely and accurate diagnoses to farmers and agricultural professionals, enabling them to take appropriate measures to mitigate the spread and impact of diseases on their tomato crops. The system employs AI techniques such as machine learning and pattern recognition to improve its diagnostic capabilities. The AI system learns to recognize patterns and correlations between symptoms and diseases, enabling it to make accurate predictions based on new input data. The expert system is designed to be user-friendly, allowing farmers and agricultural professionals to input symptoms they observe in their tomato plants. The system processes this input, compares it with the knowledge base (KB) and machine learning models, and generates a probable diagnosis along with recommended treatments or preventive measures. The expert system aims to revolutionize tomato disease management by providing a reliable and efficient tool for early and accurate diagnosis, leading to better disease control and increased crop yield for farmers.

Plant disease detection using machine learning approaches [3] involves the application of advanced computational techniques, particularly machine learning algorithms like Convolutional Neural Networks (CNNs), to identify and diagnose diseases in plants. This innovative approach utilizes datasets comprising images or sensor data to train models that can recognize patterns and features associated with specific plant diseases. Through the training process, these models learn to differentiate between healthy and diseased plants. Once trained, they can accurately predict and diagnose diseases in new plant samples based on the symptoms observed. Continuous improvement and updates are integral to enhancing the accuracy and effectiveness of these machine learning models, ensuring their valuable contribution to agriculture by enabling timely disease management and optimizing crop yields.

The research [4] discusses creating an expert system to find diseases in chili plants. The project focuses on combining information, facts, and search approaches for disease identification using artificial intelligence and rule-based reasoning. For farmers in the chili sector, the expert system is intended as a web-based program with the goal of offering prompt,

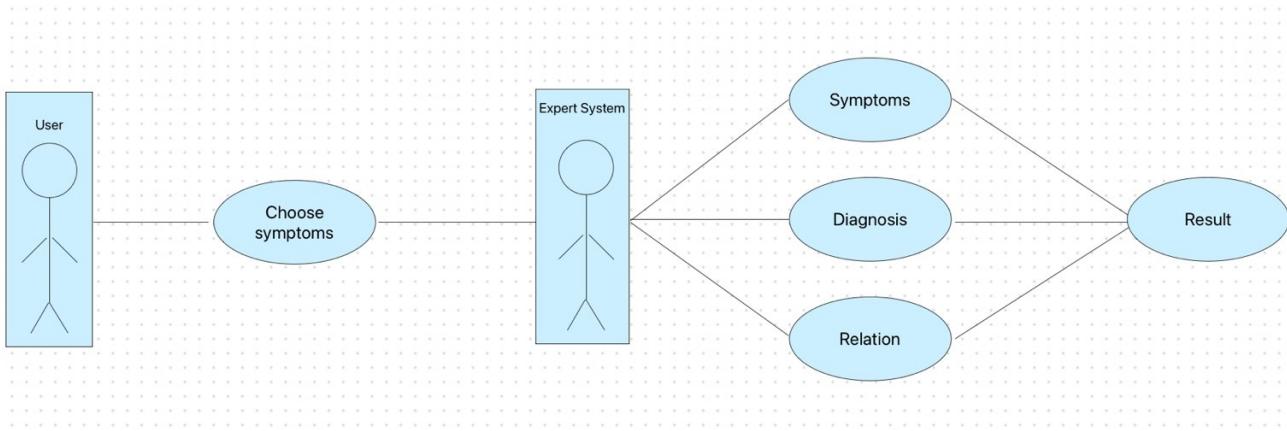
precise, and accurate responses. The methodology is described in the study, which also includes data collection via observations and discussions with plant experts. A description of the system's architecture is given, emphasizing elements like the user interface, knowledge base, knowledge acquisition, and inference engine. The research indicates that the expert system may effectively handle the issues faced by chili growers in disease diagnosis and control, delivering reliable information based on expert knowledge and saving costs.

A State of Art Survey on Plant Leaf Disease Detection [5] provides a comprehensive overview and analysis of the most current and advanced techniques, methodologies, and technologies in the field of automated plant leaf disease detection. The survey encompasses various approaches, including traditional image processing methods and state-of-the-art machine learning techniques, utilized to identify and diagnose diseases affecting plant leaves. Researchers and practitioners compile extensive datasets consisting of images of diseased and healthy plant leaves. These datasets serve as the foundation for training machine learning models, which include deep learning (DL) algorithms such as Convolutional Neural Networks (CNNs). CNNs, with their ability to learn intricate patterns and features, have demonstrated exceptional performance in plant leaf disease detection.

In summary, a State of Art Survey on Plant Leaf Disease Detection provides valuable insights into the evolving landscape of automated disease detection in plant leaves. It encompasses cutting-edge methodologies and technologies, paving the way for more effective and efficient disease management in the agricultural sector.

## Chapter 3: System development and implementation

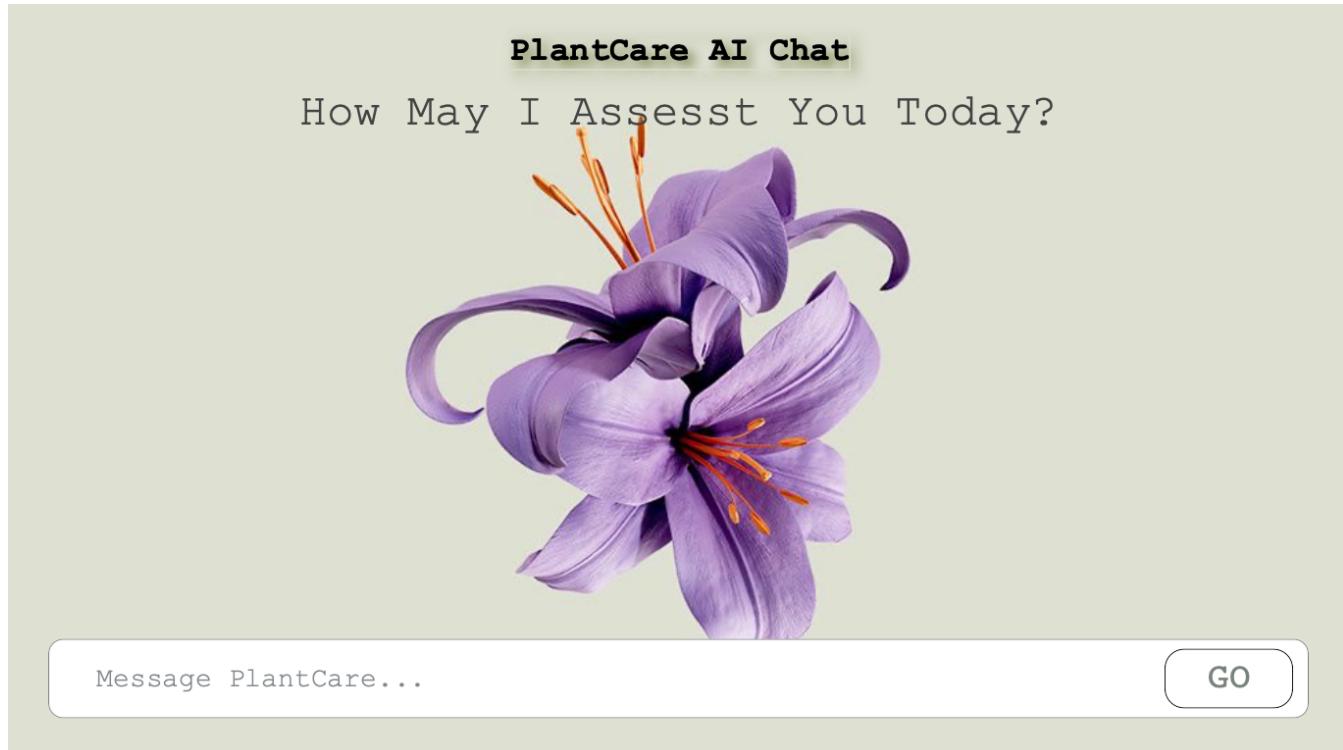
### 3.1 System development



**Figure 1:** PlantCare use case diagram.

In **Figure 1** the user must choose a symptom given from the expert system. Based on the user's responses, the expert system will analyze the symptoms following by the plant diagnosis and the relation between them giving the user a full plant diagnosis.

### 3.2 System Prototype



**Figure 2:** PlantCare prototype

In **Figure 2** the user shall receive a main menu that consists of questions from the AI system regarding the plant name, diseases, recommendation and location. Therefore, based on the user's answers, the expert system will conclude the plant diagnosis as well as providing useful suggestions.

### 3.3 System Component

**Input:** It will be based on the answers received from the user, such as:

- Identify the plant health issue? The user will answer with the plant name
- Get personalized recommendation “Treatments”? The user will answer with the plant name.
- Determine the plant location (indoor, outdoor)? The user will answer with the plant name.
- Identify the disease and all related plants? The user will answer with the disease name.

**Process:** The expert system will take these answers to analyze and retrieve them based on a knowledge-based system (KBSee), after that, it will display the results.

**Output:** based on the expert system knowledge and the user entered data (facts), the system will suggest diagnoses and recommendations to the users on how to deal with the current problem.

### 3.4 System Flowchart

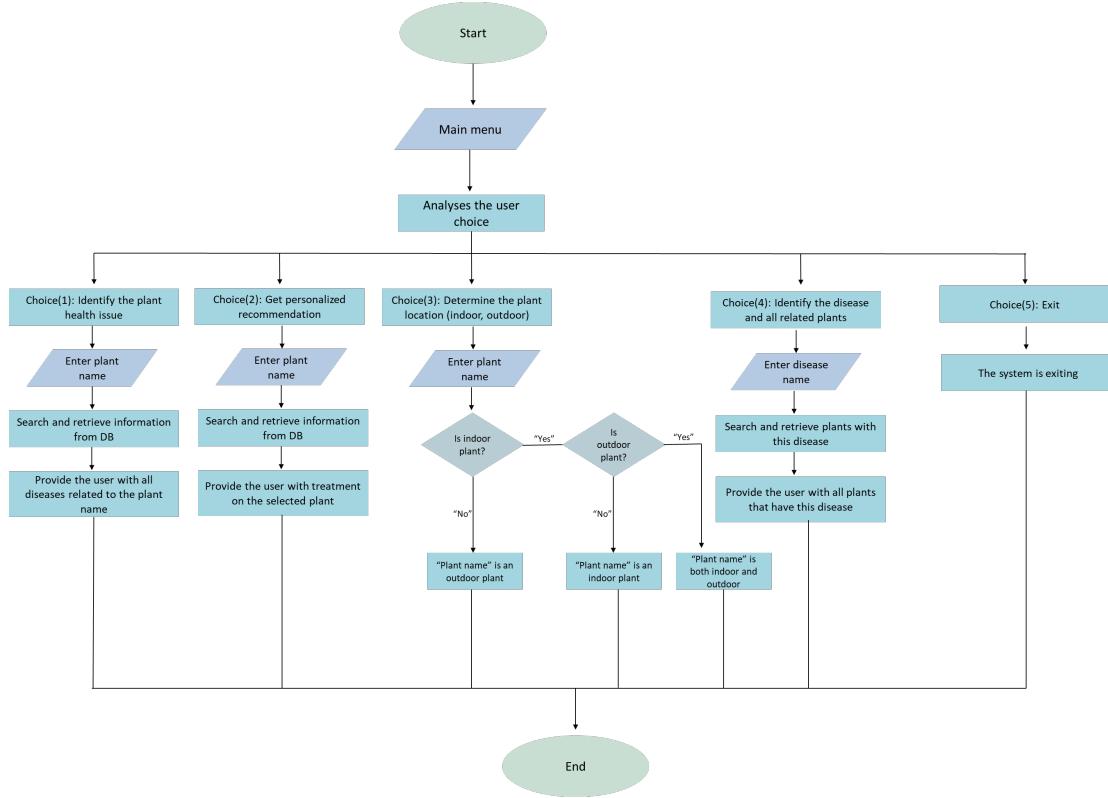


Figure 3: Flowchart system

**Figure 3** describes the flowchart of the system, where the system starts with the main menu and then the user has multiple options (1–5), so the choice must be entered. And according to the user's choice, the system will perform different tasks, such as identifying the problem of plant health and determining if the plant is indoor or outdoor and others as shown in the Figure above.

### 3.2 Data

The data implemented and used in the **PlantCare** system were collected from reliable plant specialized books, academic papers and gardening and houseplants expertise as referenced in **Table 3**. Once the knowledge has been gathered and carefully examined, it was implemented in the system. Furthermore, The **PlantCare** dataset consists of 48 plants including their ideal grown location and the ID of possible diseases as shown in **Table 2** as well as diseases of total 10 in plants and their treatment as shown in **Table 3** below.

#### 3.2.1 Plant Location Data Table

NO.	Plant	Location	ID of Possible Disease

1	Tomato	Outdoor	1, 3, 9
2	Daisy	Outdoor	1
3	Basil	Outdoor	1
4	Sage	Outdoor	1
5	Potato blight	Outdoor	1
6	Zinnia	Outdoor	8
7	Carrot	Outdoor	8
8	Petunia	Outdoor	8
9	Chrysanthemum	Outdoor	8
10	Celery	Outdoor	8, 9
11	Figs	Outdoor	9
12	Cucumbers	Outdoor	9
13	Peppers	Outdoor	9
14	Cereals	Outdoor	10
15	Forage grasses	Outdoor	10
16	Turf grasses	Outdoor	10
17	Lilac	Outdoor	7
18	linden	Outdoor	7
19	Daylilies	Outdoor	6
20	Snapdragons	Outdoor	6
21	Pines	Outdoor	6

22	Jasmine	Outdoor	5
23	Morning Glory	Outdoor	5
24	Olive Tree	Outdoor	5
25	Hibiscus	Outdoor	5
26	Parsley	Outdoor	5
27	Carnation	Outdoor	5
28	Lily	Outdoor	5
29	Peony	Outdoor	4
30	Macadamia	Outdoor	4
31	Passionfruit	Outdoor	4
32	Mango	Outdoor	4
33	Lychee	Outdoor	4
34	Peas	Outdoor	2
35	Apple	Outdoor	2
36	Hydrangea	Outdoor	2
37	Honeysuckle	Outdoor	2
38	Grapes	Outdoor	3
39	Blackberries	Outdoor	3
40	Czrnations	Outdoor	6
41	Maple Tree	Outdoor	7
42	Rose	Both	2, 4, 5, 6

43	Gooseberry	Both	2,3
44	Barberry	Both	7
45	Courgettes	Both	2
46	Strawberries	Indoor	3
47	Mint	Indoor	5
48	Parsley	Indoor	5

*Table 2: Plant Location*

### 3.2.2 Plant Diseases and Treatment Table

ID	Disease	What the Disease Causes	Treatment
1	<i>Fungus-like disease [6]/[14]</i>	<i>Shrivel leaves and Brown rotting</i>	<ul style="list-style-type: none"> <li><i>Avoid watering the plants from above to help keep the leaves dry. setting up a drip irrigation system provides regular watering without getting the foliage wet.</i></li> <li><i>Maximize airflow between the plants by giving them plenty of space. Tie vines to a trellis or cane support to help keep them off the ground.</i></li> <li><i>If possible, bring the plants into the greenhouse to help prevent them from catching blight and ruining your produce. If you do find blight, remove the infected plants to prevent the spread to others.</i></li> </ul>
2	<i>Powdery mildew (fungal disease) [6]/[14]</i>	<i>Powdery mildew forms a white or grey powdery coating of spots</i>	<ul style="list-style-type: none"> <li><i>Mulching, balanced feeding, and regular watering will help deter this unattractive disease.</i></li> <li><i>On ornamental plants, spray the infected plant with Fungus Clear between April and September.</i></li> <li><i>Prune out and dispose of infected shoots as soon as you see them, but don't compost them. Raking up and destroying fallen infected leaves in autumn will help reduce spores spreading the following spring.</i></li> </ul>
3	<i>Grey Mold [6]/[14]</i>	<i>Humid Conditions and causes plants overcrowded</i>	<ul style="list-style-type: none"> <li><i>Improving the ventilation in a greenhouse should help reduce the risk of Mold.</i></li> <li><i>Prune off any moldy leaves, buds or fruit as soon as you see it and burn them, and don't forget to clean your tools afterwards.</i></li> <li><i>Reduce overcrowding of plants and allow for better ventilation and reduce humidity to prevent Mould establishing.</i></li> </ul>
4	<i>Black Spots [7]/[14]</i>	<i>Black spots</i>	<i>The fungus Diplocarpon rosae.</i>

5	<i>Aphids</i> [8][14]	<i>Sap-sucking insects</i>	<ul style="list-style-type: none"> <li>• <i>Environmental Conditions: Warm temperatures and high humidity favor aphid reproduction.</i></li> <li>• <i>Lack of Natural Predators: Low populations of natural predators allow aphid numbers to increase.</i></li> <li>• <i>Over-fertilization: Excessive nitrogen-rich fertilizers attract aphids to lush plant growth.</i></li> <li>• <i>Chemical Attractants: Volatile chemicals released by attacked plants attract more aphids.</i></li> <li>• <i>Overcrowding: Planting too closely creates favorable conditions for aphids.</i> <ul style="list-style-type: none"> <li>• <i>Previous Infestations: Residual aphids or eggs from prior infestations contribute to recurring problems.</i></li> </ul> </li> </ul>
6	<i>Rust</i> [9][14]	<ol style="list-style-type: none"> <li>1. <i>Moisture: Rust thrives in humid and moist conditions, requiring water for spore germination.</i></li> <li>2. <i>Overhead Watering: Watering from above keeps foliage wet, promoting rust development.</i></li> <li>3. <i>Poor Air Circulation: Dense plantings limit air movement, creating a conducive environment.</i></li> </ol>	<ul style="list-style-type: none"> <li>• <i>Purchases a Fungicides and use it on the infected plant</i></li> <li>• <i>Gather and destroy any infected plants to prevent the fungus from overwintering.</i> <ul style="list-style-type: none"> <li>• <i>Pick or prune away any affected leaves as soon as you see them.</i></li> </ul> </li> </ul>
7	<i>Verticillium Wilt</i> [10][14]	<i>The soil-borne fungi Verticillium dahliae and V. albo-atrum</i>	<i>There is no effective treatment for verticillium wilt.</i>
8	<i>Aster yellows</i> [11][14]	<i>Aster yellows</i>	<i>Candidatus Phytoplasma asteris.</i>
9	<i>Mosaic Virus</i> [12][14][15]	<i>The mosaic virus</i>	<i>There are no cures for viral diseases, such as the mosaic virus, once a plant is infected.</i>
10	<i>Snow mold</i> [13][14]	<i>Soilborne fungi</i>	<i>Gently rake the affected areas of the lawn with a leaf rake.</i>

*Table 3: Plant Diseases and Treatment*

### 3.3 Tools

Our system was implemented using the following tool:

Tool	Purpose

Swish Prolog	By applying logical processes, the Swish prolog examines the rules and the facts.
--------------	---

*Table 4: Tools implemented in PlantCare System*

### **3.4 Implementation**

Using Swish Prolog, the **PlantCare** system has been designed and implemented to make accurate decisions easier to track, understand, and use. Prolog accomplished this, as it can use facts and rules as a knowledge base and analyze user queries using the facts and rules declared in the database.

#### **3.4.1 Raw Data**

Detailed data and ‘**PlantCare**’ system source code are provided in the appendices.

#### **3.4.2 Facts**

The facts implemented in **PlantCare** system regarding the plant's location, diseases, and their respective treatments are shown below from **Figure 4** to **Figure 9**.

```
4 plant(tomato, outdoor).
5 plant(daisy, outdoor).
6 plant(basil, outdoor).
7 plant(sage, outdoor).
8 plant(potato_blight, outdoor).
9 plant(courgettes, both).
10 plant(peas, outdoor).
11 plant(apple, outdoor).
12 plant(gooseberry, both).
13 plant(hydrangea, outdoor).
14 plant(rose,both).
15 plant(honeysuckle, outdoor).
16 plant(strawberries, indoor).
17 plant(grapes,outdoor).
18 plant(peony,outdoor).
19 plant(blackberries, outdoor).
20 plant(tomatoes,outdoor).
21 plant(macadamia, outdoor).
22 plant(passionfruit, outdoor).
23 plant(mango,outdoor).
24 plant(lychee,outdoor).
25 plant(jasmine, outdoor).
26 plant(morning_glory,outdoor).
27 plant(olive_tree,outdoor).
28 plant(hibiscus, outdoor).
29 plant(olive_tree, outdoor).
30 plant(mint, indoor).
31 plant(parsley, indoor).
32 plant(carnation, outdoor).
33 plant(lily, outdoor).
34 plant(daylilies, outdoor).
35 plant(snapdragons, outdoor).
36 plant(pines, outdoor).
37 plant(czrnations, outdoor).
38 plant(maple_tree, outdoor).
```

*Figure 4: indoor/outdoor plant facts code*

```

39 plant(barberry, both).
40 plant(lilac, outdoor).
41 plant(linden, outdoor).
42 plant(zinna, outdoor).
43 plant(carrot, outdoor).
44 plant(petunia, outdoor).
45 plant(chrysanthemum, outdoor).
46 plant(celery, outdoor).
47 plant(figs, outdoor).
48 plant(cucumbers, outdoor).
49 plant(papers, outdoor).
50 plant(cereals, outdoor).
51 plant(forage_grasses, outdoor).
52 plant(truf_grasses, outdoor).

```

**Figure 5:** Indoor/Outdoor plant facts code

```

92 % Verticillium Wilt disease
93 problem(verticillium_wilt,maple_tree).
94 problem(verticillium_wilt,barberry).
95 problem(verticillium_wilt,lilac).
96 problem(verticillium_wilt,linden).
97 % Aster Yellows disease
98 problem(aster_yellows,zinnia).
99 problem(aster_yellows,carrot).
100 problem(aster_yellows,petunia).
101 problem(aster_yellows,chrysanthemum).
102 problem(aster_yellows,celery).
103 % Mosaic Virus disease
104 problem(mosaic_virus,figs).
105 problem(mosaic_virus,tomato).
106 problem(mosaic_virus,celery).
107 problem(mosaic_virus,cucumbers).
108 problem(mosaic_virus,peppers).
109 % Snow Mold disease
110 problem(snow_mold,cereals).
111 problem(snow_mold,forage_grasses).
112 problem(snow_mold,turf_grasses).
113 % Aphids disease
114 problem(aphids,rose).
115 problem(aphids,jasmine).
116 problem(aphids,morning_glory).
117 problem(aphids,olive_tree).
118 problem(aphids,hibiscus).
119 problem(aphids,mint).
120 problem(aphids,parsley).
121 problem(aphids,carnation).
122 problem(aphids,lily).
--
```

**Figure 6:** Plant diseases facts code

```

58 % Fungus-Like disease
59 problem(fungus_like,tomato).
60 problem(fungus_like,daisy).
61 problem(fungus_like,basil).
62 problem(fungus_like,sage).
63 problem(fungus_like,potato_blight).
64 % Powdery mildew(fungal disease)
65 problem(powdery_mildew,courgettes).
66 problem(powdery_mildew,peas).
67 problem(powdery_mildew,apple).
68 problem(powdery_mildew,gooseberry).
69 problem(powdery_mildew,hydrangea).
70 problem(powdery_mildew,rose).
71 problem(powdery_mildew,honeysuckle).
72 % Grey mold disease
73 problem(grey_mold,strawberries).
74 problem(grey_mold,grapes).
75 problem(grey_mold,gooseberries).
76 problem(grey_mold,blackberries).
77 problem(grey_mold,tomato).
78 % Black Spots disease
79 problem(black_spots,peony).
80 problem(black_spots,macadamia).
81 problem(black_spots,passionfruit).
82 problem(black_spots,mango).
83 problem(black_spots,lychee).
84 problem(black_spots,rose).
85 % Rust disease
86 problem(rust,daylilies).
87 problem(rust,snapdragons).
88 problem(rust,pines).
89 problem(rust,rose).
90 problem(rust,cznations).

```

*Figure 7: Plant diseases facts code*

```

127 #Fungus Like disease treatments
128 recommendation(fungus_like,
129 '1- Avoid watering the plants from above to help keep the leaves dry.
130 2- Maximise airflow between the plants by giving them plenty of space.
131 Tie vines to a trellis or cane support to help keep them off the ground.
132 3- If possible, bring the plants into the greenhouse to help prevent them
133 from catching blight and ruining your produce.
134 4- remove the infected plants to prevent the spread of the fungus.' ).
135
136 #Powdery Mildew disease treatments
137 recommendation(powdery_mildew,
138 '1- Mulching, balanced feeding, and regular watering will help deter this unattractive disease.
139 2- On ornamental plants, spray the infected plant with Fungus Clear between April and September.
140 3- Prune out and dispose of infected shoots as soon as you see them, but don't compost them.
141 Raking up and destroying fallen infected leaves in autumn will help reduce the spread of spores.' .
142
143 #Grey Mold Disease Treatments
144 recommendation(grey_mold,
145 '1- Improving the ventilation in a greenhouse should help reduce the risk of mold.
146 2- Prune off any moldy leaves, buds, or fruit as soon as you see it and burn them,
147 and don't forget to clean your tools afterward.
148 3- Reduce overcrowding of plants allow for better ventilation
149 and reduce humidity to prevent mould establishing.' .
150
151 #Black Spots disease Treatments
152 recommendation(black_spots,
153 '1- The fungus overwinters in diseased canes and leaves, so remove both before winter.
154 2- Keep foliage clean and dry by mulching beneath plants, positioning roses where the morning
155 sun will quickly evaporate dew, and watering at the roots rather than wetting the foliage.
156 3- Consider planting varieties of roses that are resistant to black spots.
157 4- Spray the plants with a fungicide to prevent black spots.' .

```

*Figure 8: Plants Disease Treatments facts code*

```

151 *Black Spots disease Treatments
152 recommendation(black_spots,
153 1- The fungus overwinters in diseased canes and leaves, so remove both before winter.
154 2- Keep foliage clean and dry by mulching beneath plants, positioning roses where the morning
155 sun will quickly evaporate dew, and watering at the roots rather than wetting the foliage.
156 3- Consider planting varieties of roses that are resistant to black spots.
157 4- Spray the plants with a fungicide to prevent black spots.' ).
158
159 *Aphids Disease Treatments
160 recommendation(aphids,
161 1- Biological Control: Introduce natural predators or attract beneficial insects.
162 2- Neem Oil: Disrupts aphid feeding and acts as a repellent.
163 Insecticidal Soaps: Break down aphid protective layers, causing dehydration.
164 3- Spraying with Water: Dislodge aphids with a strong water stream, focusing on leaf undersides.
165 4- Companion Planting: Plant species that repel aphids near susceptible crops.' .
166
167 *Rust Disease Treatments
168 recommendation(rust,
169 1- Purchase a Fungicides and use it on the infected plant
170 2-Gather and destroy any infected plants to prevent the fungus from overwintering.
171 3- Pick or prune away any affected leaves as soon as you see them.' .
172
173 * Verticillium Wilt Disease Treatments
174 recommendation(verticillium_wilt,
175 Unfortunately, there is no effective treatment for verticillium wilt.' .
176
177 *Aster Yellows Disease Treatments
178 recommendation(aster_yellows,
179 Unfortunately, there is no effective treatment for aster yellows.' .
180
181 *Mosaic Virus disease Treatments
182 recommendation(mosaic_virus, 'Once a plant is infected, there are no cures for viral diseases, such as the mosaic virus.' .
183
184 *Snow Mold disease Treatments
185 recommendation(snow_mold, 'Gently take the affected areas of the lawn with a leaf rake.' ).
```

**Figure 9: Plants Disease Treatments facts code**

### 3.4.3 Rules

The rules implemented in **PlantCare** system are shown below from **Figure 10** to **Figure 16** with its explanation above each code.

```

189 * Rules to identify the plant health issues
190 identify_problem(Plant, Issue) :-  
191     problem(Issue, Plant).
192
193 * Rules to provide a personalized recommendations (treatments) bases on the plant diseases
194 get_recommendation(Plant, Recommendation) :-  
195     identify_problem(Plant, Issue),
196     recommendation(Issue, Recommendation).
197
198 * Rules to determine if a plant is considered an indoor or outdoor plant, base on the database of our system
199
200 *If a Plant is Indoor
201 is_indoor_plant(Plant) :-  
202     plant(Plant, indoor),!.
203
204 *If a Plant is Outdoor
205 is_outdoor_plant(Plant) :-  
206     plant(Plant, outdoor).
207
208 *If a Plant is both outdoor and indoor
209 is_both_plant(Plant):-  
210     plant(Plant, both).
211
212 * Rule to find plants with a specific problem
213 plants_with_problem(Problem, Plants) :-  
214     setof(Plant, problem(Problem, Plant), Plants).
215
216 * Rule to find diseases for a specific plant
217 diseases_for_plant(Plant, Diseases) :-  
218     setof(Problem, problem(Problem, Plant), Diseases).
219
220 * Rules to assist users in improving plant care practices
221 assist(Plant) :-  
222     diseases_for_plant(Plant, Diseases),
223     format('Plant: ~w~n', [Plant]),
224     format('Diseases: ~w~n', [Diseases]).
```

**Figure 10: Plants rules code**

### 3.4.4 Start Code

**Figure 11** shows the ‘main\_menu’ which represents the start statement of PlantCare system.

```
227 | % Main menu that will be displayed on the uses screen
228 | main_menu:-|
229 |
230 |     write(''), nl,
231 |     write('--- Welcome to PlantCare ---'), nl,
232 |     write(' A Plant Health Diagnosis Expert System'), nl,
233 |     write('Our goal is to create a comprehensive and efficient')
234 |     tool that uses expert knowledge to diagnose and identify plant health issues. '), nl,
235 |     write('Kindly select your choice from (1-5) '), nl,
236 |     write('1. Identify the plant health issue'), nl,
237 |     write('2. Get personalized recommendation'), nl,
238 |     write('3. Determine the plant location (indoor, outdoor)'), nl,
239 |     write('4. Identify the disease and all realted plants'), nl,
240 |     write('5. Exit'), nl.
```

**Figure 11:** Start statement code of PlantCare system.

Based on the users input of the numbers running from (1-4), each number will display a certain execution. If the user input is (1) and the plant name is typed, the system will retrieve information from the database and present all the issues the plant can face as shown in **Figure 12** below.

```
245 | selected_choice(1) :-|
246 |
247 |     write('Enter the name of a plant: '),
248 |     read(Plant),
249 |     assist(Plant), !.
```

**Figure 12:** Choice 1 code of PlantCare system.

If the user's choice of input is (2) and the plant name is typed, the system will retrieve information from the database and present its recommendation or "Treatments " as shown in **Figure 13** below.

```
254 | selected_choice(2) :-|
255 |
256 |     write('Kindly Enter The Plant Name: '),
257 |     read(Plant),
258 |     get_recommendation(Plant, Recommendation),
259 |     format('Recommendation for ~w: ~w-n', [Plant, Recommendation]), !.
```

**Figure 13:** Choice 2 code of PlantCare system.

If the user's choice of input is (3) and the plant name is typed, the system will retrieve information from the database and present the type of the plant based on the location (indoor, outdoor) as shown in **Figure 14** below.

```

264 selected_choice(3) :-
265
266     write('Kindly Enter The Plant Name: '),
267     read(Plant),
268     (is_indoor_plant(Plant) ->
269         format('~w is an indoor plant.-n', [Plant])
270     ; is_outdoor_plant(Plant) ->
271         format('~w is an outdoor plant.-n', [Plant])
272     ; is_both_plant(Plant) ->
273         format('~w is both indoor and outdoor plant.-n', [Plant])
274     ;
275         format('Location information not available for ~w.-n', [Plant])
276     ), !.

```

**Figure 14:** Choice 3 code of PlantCare system.

If the user's choice of input is (4) and the plant disease name is typed, the Expert system will retrieve information from the database and present all plants that have the disease in common as shown in **Figure 15** below.

```

283 selected_choice(4) :-
284     write('Enter the name of the plant disease: '),
285     read(Disease),
286     plants_with_problem(Disease, Plants),
287     format('Plants with the problem ~w: ~w-n', [Disease, Plants]), !.

```

**Figure 15:** Choice 4 code of PlantCare system.

If the user's choice of input is (5), the expert system will exit the program as shown in **Figure 16** in line 291 to 292. While the line from 294 to 295 shows the output if the user enters a number outside the range of (1-5).

```

291 selected_choice(5) :-
292     write('The Expert System is Exiting... .') , !.
293
294 selected_choice(_) :-
295     write('Invalid choice. Please try again.'), nl , !.

```

**Figure 16:** Choice 5 and retry code of PlantCare system.

### **3.5 Testing**

Our system has been tested in a variety of scenarios, including determining whether a plant is indoor or outdoor and identifying the health issue. Additionally, for individuals who are interested in plant diseases and health, our system provides the ability to identify diseases, indicates all plants exposed to them, and generates recommendations for various kinds of plants. **Figure 18 to Figure 28** below displays 5 test cases for the plant health diagnosis system.

#### **3.5.1 Start output:**

```
--- Welcome to PlantCare ---
A Plant Health Diagnosis Expert System
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to
diagnose and identify plant health issues.
Kindly select your choice from (1-5)
1. Identify the plant health issue
2. Get personalized recommendation
3. Determine the plant location (indoor, outdoor)
4. Identify the disease and all realted plants
5. Exit
```

**Figure 17: Start output**

#### **3.5.2 Test cases:**

##### **3.5.2.1 Case 1: Identify the plant health issue:**

**Figure 18** below shows a test case for the first case where the user enters the name of the plant and then the potential problems or diseases affecting the health of the plant will be identified.

```
--- Welcome to PlantCare ---
A Plant Health Diagnosis Expert System
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to
diagnose and identify plant health issues.
Kindly select your choice from (1-5)
1. Identify the plant health issue
2. Get personalized recommendation
3. Determine the plant location (indoor, outdoor)
4. Identify the disease and all realted plants
5. Exit
|, 1.
Enter the name of a plant: |, rose.
Plant: rose
Diseases: [aphids,black_spots,powdery_mildew,rust]
```

**Figure 18 Case 1: Rose plant**

--- Welcome to PlantCare ---  
A Plant Health Diagnosis Expert System  
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to diagnose and identify plant health issues.  
Kindly select your choice from (1-5)  
1. Identify the plant health issue  
2. Get personalized recommendation  
3. Determine the plant location (indoor, outdoor)  
4. Identify the disease and all realted plants  
5. Exit  
|, 1.  
Enter the name of a plant: |, blackberries.  
Plant: blackberries  
Diseases: [grey\_mold]

**Figure 19 Case 1: Blackberries plant**

### **3.5.2.2 Case 2: Get a personalized recommendation:**

**Figure 20 and Figure 21** below show a test case for the second case and provide the user with a suitable recommendation for plant care.

--- Welcome to PlantCare ---  
A Plant Health Diagnosis Expert System  
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to diagnose and identify plant health issues.  
Kindly select your choice from (1-5)  
1. Identify the plant health issue  
2. Get personalized recommendation  
3. Determine the plant location (indoor, outdoor)  
4. Identify the disease and all realted plants  
5. Exit  
|, 2.  
Kindly Enter The Plant Name: |, mango.  
Recommendation for mango:  
1- The fungus overwinters in diseased canes and leaves, so remove both before winter.  
  
2- Keep foliage clean and dry by mulching beneath plants, positioning roses where the morning sun will quickly evaporate dew, and watering at the roots rather than wetting the foliage.  
  
3- Consider planting varieties of roses that are resistant to black spots.  
  
4- Spray the plants with a fungicide to prevent black spots.

**Figure 20 Case 2: Recommendation for mango plant**

--- Welcome to PlantCare ---  
A Plant Health Diagnosis Expert System  
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to diagnose and identify plant health issues.  
Kindly select your choice from (1-5)  
1. Identify the plant health issue  
2. Get personalized recommendation  
3. Determine the plant location (indoor, outdoor)  
4. Identify the disease and all realted plants  
5. Exit  
|, 2.  
Kindly Enter The Plant Name. |, jasmine.  
Recommendation for jasmine.  
1- Biological Control. Introduce natural predators or attract benefici insects.  
  
2- Neem Oil. Disrupts aphid feeding and acts as a repellent.  
Insecticidal Soaps. Break down aphid protective layers, causing dehydration.  
  
3- Spraying with Water. Dislodge aphids with a strong water stream, focusing on leaf undersides.  
  
4- Companion Planting. Plant species that repel aphids near susceptible crops.

**Figure 21 Case 2: Recommendation for jasmine plant**

### **3.5.2.3 Case 3: Determine the plant location (indoor, outdoor):**

Figure 22 to Figure 24 displays below show a test case for the third case where the user can enter the name of the plant and the system determines whether the plant is indoor, outdoor or both.

--- Welcome to PlantCare ---  
A Plant Health Diagnosis Expert System  
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to diagnose and identify plant health issues.  
Kindly select your choice from (1-5)  
1. Identify the plant health issue  
2. Get personalized recommendation  
3. Determine the plant location (indoor, outdoor)  
4. Identify the disease and all realted plants  
5. Exit  
|, 3.  
Kindly Enter The Plant Name. |, apple.  
apple is an outdoor plant.

**Figure 22 Case 3: Determine if an apple plant is indoor/outdoor**

--- Welcome to PlantCare ---  
A Plant Health Diagnosis Expert System  
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to diagnose and identify plant health issues.  
Kindly select your choice from (1-5)  
1. Identify the plant health issue  
2. Get personalized recommendation  
3. Determine the plant location (indoor, outdoor)  
4. Identify the disease and all realted plants  
5. Exit  
|, 3.  
Kindly Enter The Plant Name: |, parsley.  
parsley is an indoor plant.

**Figure 23 Case 3:** Determine if a parsley plant indoor/outdoor

--- Welcome to PlantCare ---  
A Plant Health Diagnosis Expert System  
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to diagnose and identify plant health issues.  
Kindly select your choice from (1-5)  
1. Identify the plant health issue  
2. Get personalized recommendation  
3. Determine the plant location (indoor, outdoor)  
4. Identify the disease and all realted plants  
5. Exit  
|, 3.  
Kindly Enter The Plant Name: |, rose.  
rose is both indoor and outdoor plant.

**Figure 24 Case 3:** Determine if a rose plant is indoor/outdoor

### **3.5.2.4 Case 4: Identify the disease and all related plants:**

**Figures 25 and 26** show a test case for the fourth case where the user can enter the name of the disease and the system displays all plants that are infected with this disease.

```
--- Welcome to PlantCare ---
A Plant Health Diagnosis Expert System
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to
diagnose and identify plant health issues.
Kindly select your choice from (1-5)
1. Identify the plant health issue
2. Get personalized recommendation
3. Determine the plant location (indoor, outdoor)
4. Identify the disease and all realted plants
5. Exit
| : 4.
Enter the name of the plant disease. |, aphids.
Plants with the problem aphids. [carnation,hibiscus,jasmine,lily,mint,morning_glory,ol
ive_tree,parsley,rose]
```

**Figure 25 Case 4: Identify the disease and all related plants**

```
--- Welcome to PlantCare ---
A Plant Health Diagnosis Expert System
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to
diagnose and identify plant health issues.
Kindly select your choice from (1-5)
1. Identify the plant health issue
2. Get personalized recommendation
3. Determine the plant location (indoor, outdoor)
4. Identify the disease and all realted plants
5. Exit
| : 4.
Enter the name of the plant disease. |, rust.
Plants with the problem rust. [cZNations,daylilies,pines,rose,snapdragons]
```

**Figure 26 Case 4: Identify the disease and all related plants**

### **3.5.2.5 Case 5: Exit the system:**

In case 5 shown in **Figure 27**, option number 5 is used to exit the system.

```
--- Welcome to PlantCare ---
A Plant Health Diagnosis Expert System
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to
diagnose and identify plant health issues.
Kindly select your choice from (1-5)
1. Identify the plant health issue
2. Get personalized recommendation
3. Determine the plant location (indoor, outdoor)
4. Identify the disease and all realted plants
5. Exit
|, 5.
The Expert System is Exiting...
true.
```

**Figure 27 Case 5: Exit the system**

### **3.5.3 Error handling:**

Error handling has been performed to avoid errors in the system as shown in **Figure 28**. When a selection number is entered that is not included in the list, a message will appear to the user "Invalid choice. Please try again.".

```
--- Welcome to PlantCare ---
A Plant Health Diagnosis Expert System
Our goal is to create a comprehensive and efficient tool that uses expert knowledge to
diagnose and identify plant health issues.
Kindly select your choice from (1-5)
1. Identify the plant health issue
2. Get personalized recommendation
3. Determine the plant location (indoor, outdoor)
4. Identify the disease and all realted plants
5. Exit
|, 6.
Invalid choice. Please try again.
```

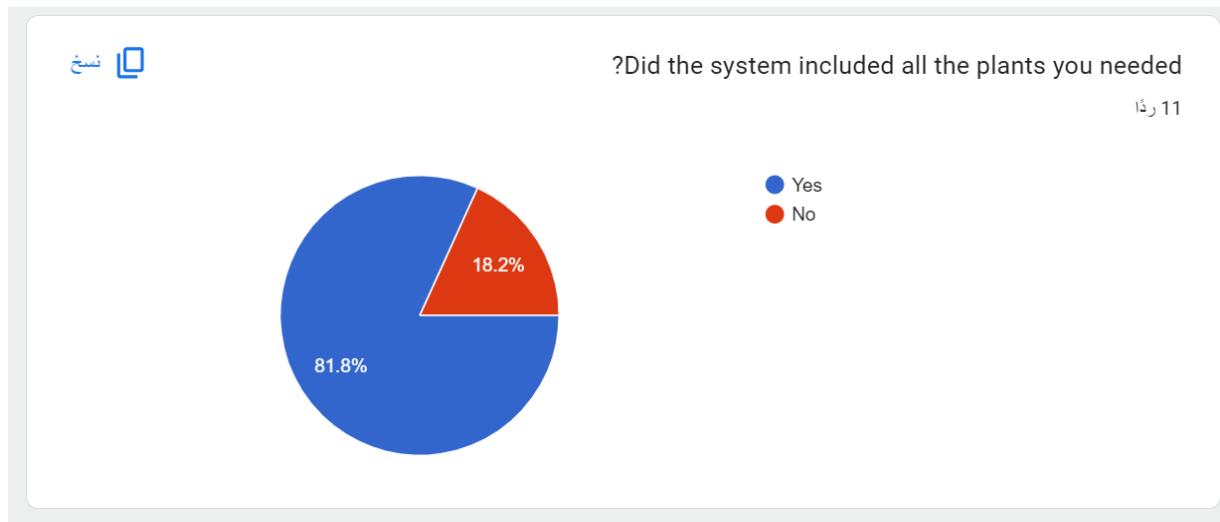
**Figure 28: Error handling**

### 3.6 Results

The PlantCare system has proven to be very effective in diagnosing plants' health diseases and in providing suitable and detailed diagnoses, as well as suggesting appropriate treatments and offering a detailed analysis of the survey results. Here is a detailed analysis of the survey results.

#### 3.6.1 Survey Analyst

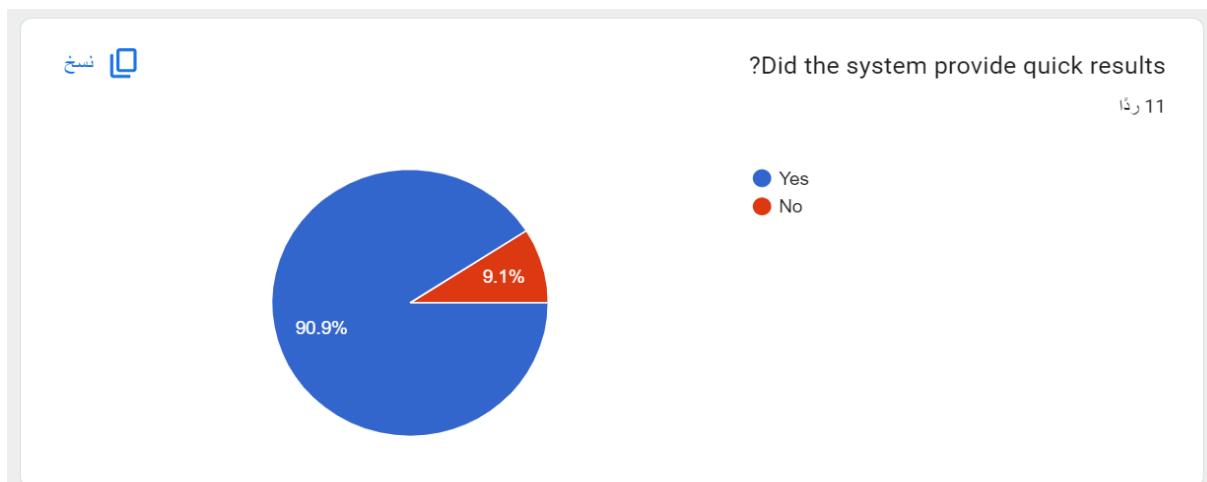
According to **Figure 29** it presents question 1 in the survey, which was “Did the system include all the plants you need?”. **81.8%** respondents indicated that the system provided all the necessary plants. Alternatively, **18.2%** of users stated that they did not find all the plants they were searching for. We aim to expand our database in the future to offer a more comprehensive plant diagnosis expert system and to hopefully score 100% in the plant database.



*Figure 29: Question1 graph.*

#### 3.6.2 Fast Result

As Shown in **Figure 30** of question 2 in the survey, **90.9%** of participants were satisfied with the system's quick response rate. Alternatively, **9.1%** unfortunately were not happy with it.



*Figure 30: Fast Result graph.*

### 3.6.3 System Satisfaction

Figure 31 shows the rate of satisfaction PlantCare received from participants, and it is noticeable that the majority, 45.5%, gave the system a rating of 5 out of 5. However, the results are equivalent to a rating of 4 out of 5. And a rate of 1 was reported by 9.1% of respondents. Accordingly, we can state that the system received favorable feedback from the majority of our testers, indicating their satisfaction.

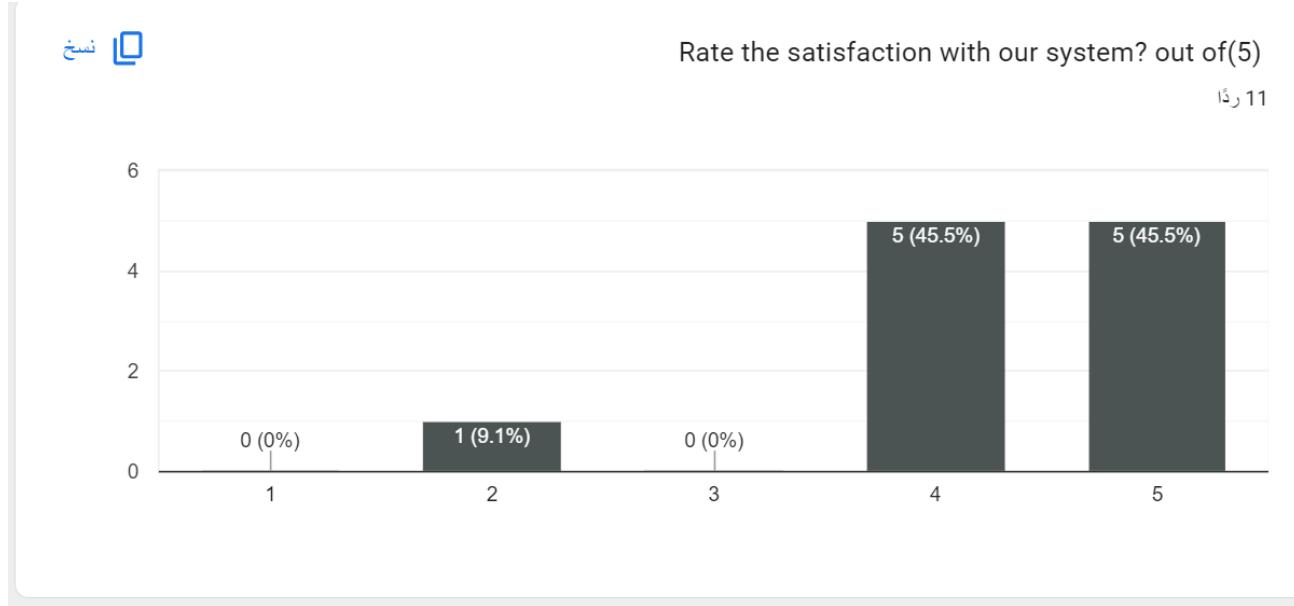


Figure 31: System Satisfaction graph.

### 3.6.4 Case sensitivity

According to Figure 32, which represents question 4 in the survey, 72.7% of respondents indicated that they didn't face any difficulties in the case-sensitivity in our expert system. Alternatively, 27.3% have faced issues in the system's case sensitivity part. As we grow our project, we hope to make our expert system case-sensitive free, to help all users find what they are looking for.

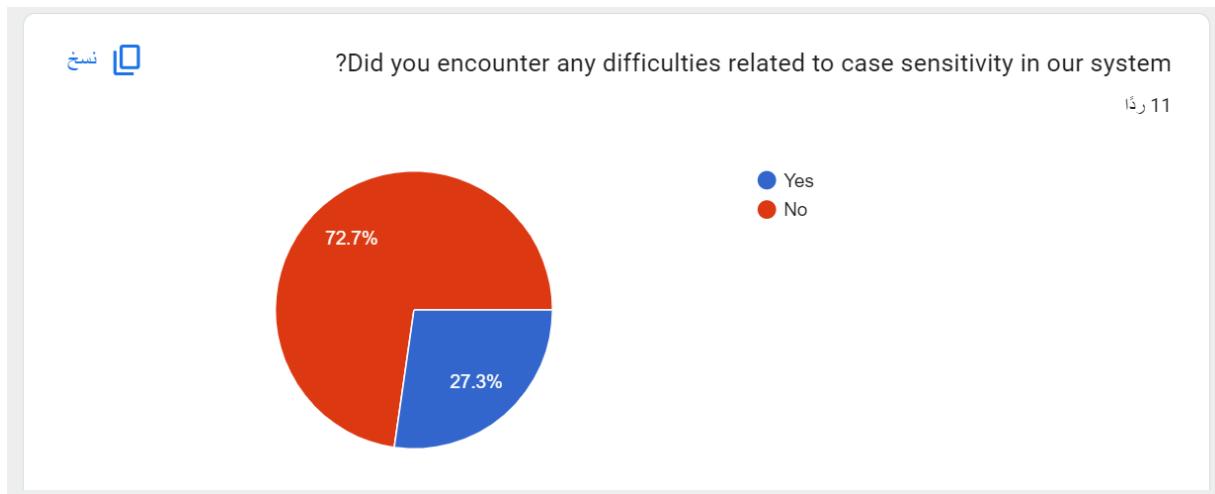


Figure 32: Case Sensitivity graph.

### 3.6.5 Accuracy Rate

Figure 34 shows the rate of accuracy received from participants, and it is clearly noticeable that the majority **54.5%** gave the system a rating of 5 out of 5. However, **36.4%** gave it a rating of 4 out of 5. And received a rate of 3 which was **9.1%**.

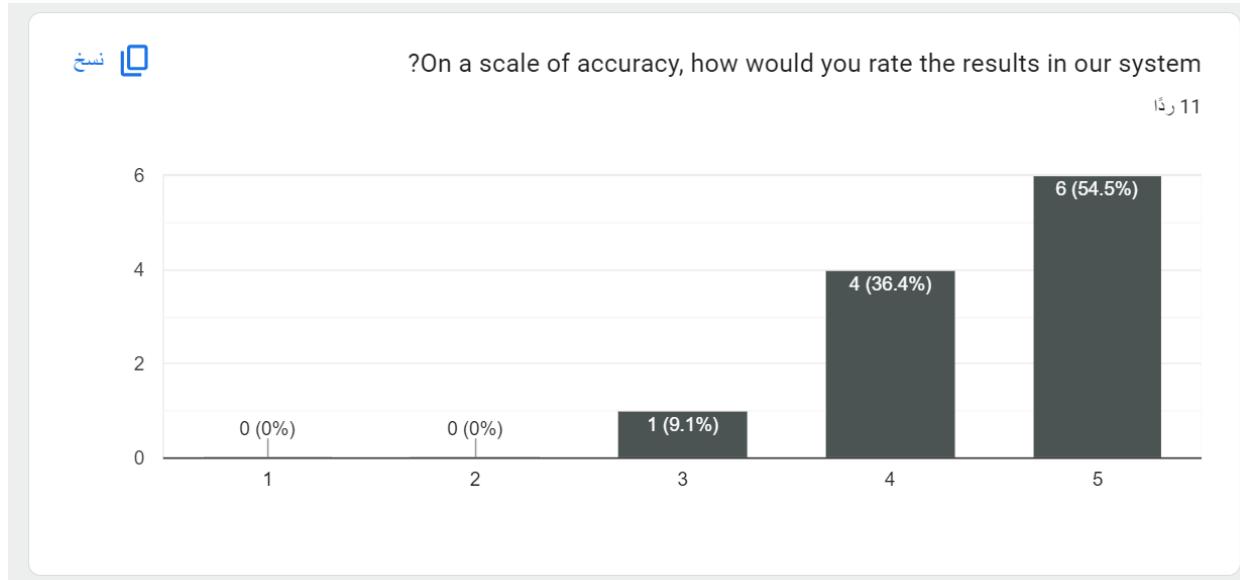


Figure 33: Accuracy Rate graph.

### 3.6.6 User friendly

Figure 35 shows the user-friendly received from participants, and it clearly noticeable that all participants gave the system **100%**. Therefore, we can state that all our testers were satisfied with the user-friendly interface within the system.

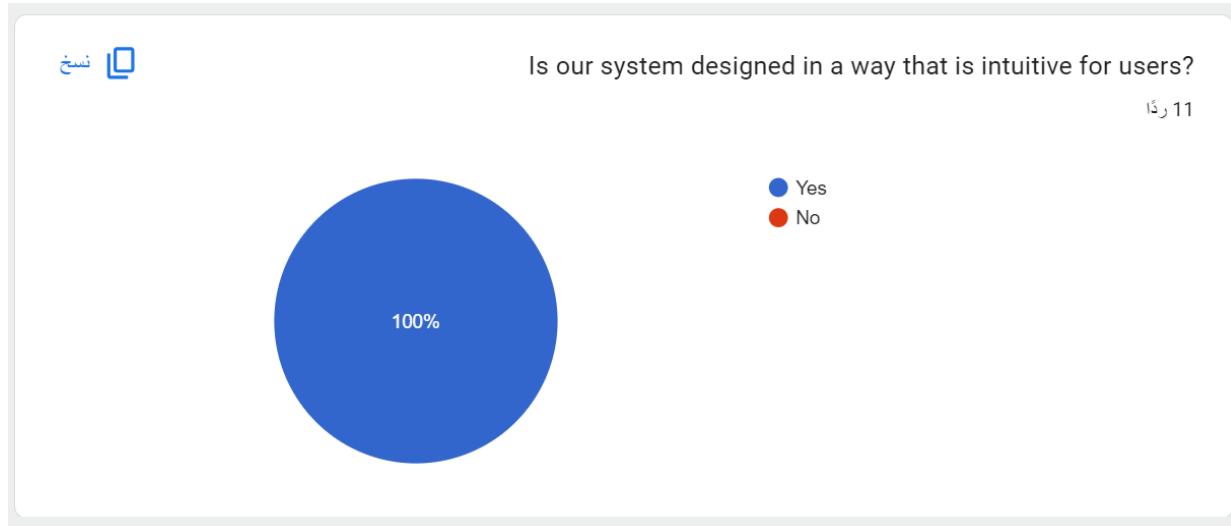
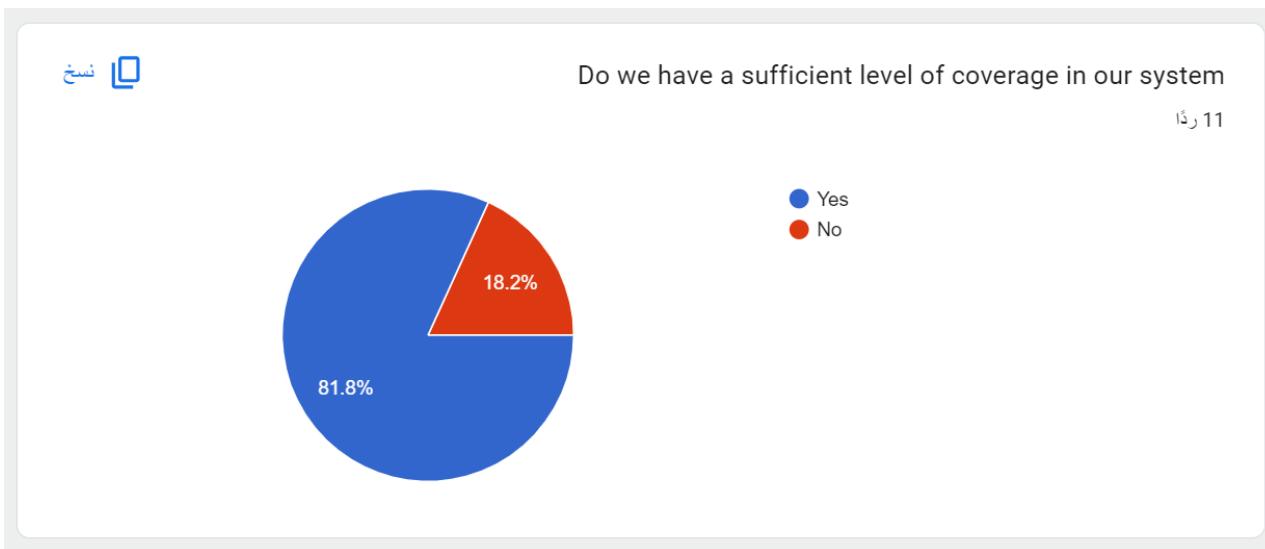


Figure 34: User Friendly graph.

### 3.6.7 Coverage Level

As shown in Figure 36 of question 7 in the survey, **81.8%** of participants were satisfied with the coverage level in the system. This indicates that the system was well received by the public. However, we received **18.2%** of participants who weren't satisfied with the coverage level.



**Figure 35:** Coverage level graph.

### 3.6.8 Final analysis:

Based on the seven analyses above, we can conclude that the system **PlantCare** has proven its worth and garnered the trust of participants in the agriculture sector. We aspire to progress and evolve our system to ensure its accessibility to a wider audience.

**The original survey and results can be found via this link:**

<https://forms.gle/Vx5D2Bb2Kb2aZWcz5>

## 3.7 Evaluation

Based on the information provided, the **PlantCare** system appears to be an effective tool for diagnosing plant problems and providing appropriate treatment recommendations. The survey highlights the system's ability to diagnose plant diseases and suggests appropriate treatments. This indicates that the system has the potential to deliver results quickly and be an asset to both professionals and home gardeners. However, the survey findings did not provide any specific data or evidence to support these claims. There was not a similar expert system in Prolog, so we designed our own, and due to narrow experiences in the plants field it led to a limited database. We could not collect all types of plants, it is almost impossible to have a comprehensive database of all the plants in the world, thus the database is small. Moreover, the scale also decreases because our system is case sensitive, for example, if a character becomes a capital letter in a word, the system will not recognize, therefore it requires further updates and improvements. Additionally, more evaluation needs to be done to evaluate the effectiveness of the **PlantCare** system once and for all. This evaluation can include comparing the system's diagnostics and treatment recommendations with those of horticultural experts or conducting clinical trials on actual plants. Overall, the information provided indicates that the **PlantCare** system has the potential to be a useful tool. However, more extreme evaluation is needed to evaluate its effectiveness. Lastly, according to the survey results and our honest judgment, we believe we have successfully developed a user-friendly interface.

## **Chapter 4: Conclusions and future work**

### **4.1 Conclusion**

In conclusion, **PlantCare** is an innovative solution to transform plant health assessment. Combining expert knowledge and artificial intelligence addresses common problems in traditional agriculture. With the assistance of the AI database and SWI-Prolog software, The **PlantCare** system was accomplished and implemented successfully. The dataset consists of 48 plants, including their ideal grown location and a total of 10 possible diseases, with a number of recommendations provided for their respective diseases. Moreover, 5 Case tests have been made in a diverse of scenarios. The result has proven to be very effective in diagnosing plants' health diseases and providing suitable and detailed diagnoses, as well as suggesting appropriate treatments and offering recommendations. Furthermore, **PlantCare** provides accurate diagnoses, customized remedies, and educational resources to improve plant health, making it an asset for farmers and the agriculture industry.

### **4.2 Future work**

The goal is to broaden our scope in the future by including a greater variety of plants, both indoor and outdoor. Furthermore, to provide complete plant health care, we also aim to increase the number of symptoms and diseases that can be identified and handled. Through user-friendly interfaces, we plan to streamline the process of diagnosing diseases in plants while making this technology accessible to both farmers and plant enthusiasts. Therefore, we believe in expanding through the development of an interactive interface that connects interactive HTML pages with SWI Prolog, enhancing the user experience overall. And hopefully in the near future we can publish a mobile version of the expert system due to its significant impact on technology, as well as to build a strong community, increasing the user's engagement and interest.

## REFERENCES

- [1] S. S. Abu-Naser, K. A. Kashkash, and M. Fayyad, "Developing an expert system for plant disease diagnosis," *Journal of Artificial Intelligence*, vol. 1, no. 2, pp. 78–85, 2008. doi:10.3923/jai.2008.78.85
- [2] Al-Qadi, M. H., El-Habibi, M. F., Megdad, M. M. M., AlQatrawi, M. J. A., Sababa, R. Z., & Abu-Naser, S. S. (2022). "Developing an Expert System to Diagnose Tomato Diseases." *International Journal of Academic Engineering Research (IJAER)*, 6(5), 34-40.
- [3] I. Ahmed and P. K. Yadav, "Plant disease detection using machine learning approaches," *Expert Systems*, vol. 40, no. 5, 2022. doi:10.1111/exsy.13136
- [4] Suhartini, I. komala dewi, and L. K. Wijaya, "Web-based expert system to detecte chili desease using rule base reasoning approach," *Journal of Physics: Conference Series*, vol. 1539, no. 1, p. 012026, 2020. doi:10.1088/1742-6596/1539/1/012026
- [5] A. Sungheetha, "State of Art Survey on Plant Leaf Disease Detection," Mendeley, <https://www.mendeley.com/catalogue/2238ec3a-d78a-3a3c-bb94-3925c61903e2/> (accessed Oct. 1, 2023).
- [6] "How to identify, treat & prevent plant diseases | Outdoor & Garden | B&Q," [www.diy.com](https://www.diy.com/ideas-advice/how-to-identify-treat-prevent-plant-diseases/PROD_npcart_100663.art). [https://www.diy.com/ideas-advice/how-to-identify-treat-prevent-plant-diseases/PROD\\_npcart\\_100663.art](https://www.diy.com/ideas-advice/how-to-identify-treat-prevent-plant-diseases/PROD_npcart_100663.art) (accessed Dec. 01, 2023).
- [7] A. and Fisheries, "Black spot," [www.business.qld.gov.au](https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/biosecurity/plants/diseases/horticultural/black-spot), Oct. 19, 2022. <https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/biosecurity/plants/diseases/horticultural/black-spot>
- [8] The Editors of Encyclopedia Britannica, "Aphid | insect," Encyclopædia Britannica. Aug. 26, 2016. Available: <https://www.britannica.com/animal/aphid>
- [9] "How to Treat Rust on Plants," HGTV. <https://www.hgtv.com/outdoors/gardens/planting-and-maintenance/how-to-treat-rust-on-plants>
- [10] L. Miller, "10 common plant diseases (and how to treat them)," Family Handyman, Sep. 08, 2023. <https://www.familyhandyman.com/list/most-common-plant-diseases/>
- [11] "Aster yellows," UMN Extension. <https://extension.umn.edu/plant-diseases/aster-yellows>
- [12] G. P. Lomonosoff and M. Shanks, "COMOVIRUSES (COMOVIRIDAE)," in Elsevier eBooks, 1999, pp. 285–291. doi: 10.1006/rwvi.1999.0054.
- [13] R. A. Zabel and J. J. Morrell, "Factors affecting the growth and survival of fungi in wood (fungal ecology)," in Elsevier eBooks, 2020, pp. 99–128. doi: 10.1016/b978-0-12-819465-2.00004-8.
- [14] Anne Marte Tronsmo, D. Collinge, A. Djurle, L. Munk, J. Yuen, and Arne Tronsmo, *Plant pathology and plant diseases*. Boston, Ma: Cab International, 2020.

[15] ŠutićD. D., Richard Earl Ford, and TošićM. T., Handbook of plant virus diseases. Boca Raton, Fla.: Crc Press, 1999.

## Appendices:

Database with its references and sources are provided in this excel sheet “[AI Plant Data.xlsx](#)“

% Facts about the plants that are available in our database

%Plants location whether its outdoor / indoor

plant(tomato, outdoor).

plant(daisy, outdoor).

plant(basil, outdoor).

plant(sage, outdoor).

plant(potato\_blight, outdoor).

plant(courgettes, both).

plant(peas, outdoor).

plant(apple, outdoor).

plant(gooseberry, both).

plant(hydrangea, outdoor).

plant(rose,both).

plant(honeysuckle, outdoor).

plant(strawberries, indoor).

plant(grapes,outdoor).

plant(peony,outdoor).

plant(blackberries, outdoor).

plant(tomatoes,outdoor).

plant(macadamia, outdoor).

plant(passionfruit, outdoor).

plant(mango,outdoor).

plant(lychee,outdoor).  
plant(jasmine, outdoor).  
plant(morning\_glory,outdoor).  
plant(olive\_tree,outdoor).  
plant(hibiscus, outdoor).  
plant(olive\_tree, outdoor).  
plant(mint, indoor).  
plant(parsley, indoor).  
plant(carnation, outdoor).  
plant(lily, outdoor).  
plant(daylilies, outdoor).  
plant(snapdragons, outdoor).  
plant(pines, outdoor).  
plant(czrnations, outdoor).  
plant(maple\_tree, outdoor).  
plant(barberry, both).  
plant(lilac, outdoor).  
plant(linden, outdoor).  
plant(zinna, outdoor).  
plant(carrot, outdoor).  
plant(petunia, outdoor).  
plant(chrysanthemum, outdoor).  
plant(celery, outdoor).  
plant(figs, outdoor).  
plant(cucumbers, outdoor).  
plant(papers, outdoor).  
plant(cereals, outdoor).  
plant(forage\_grasses, outdoor).  
plant(truf\_grasses, outdoor).

% Facts about the plant health disease

% Fungus-Like disease

problem(fungus\_like,tomato).

problem(fungus\_like,daisy).

problem(fungus\_like,basil).

problem(fungus\_like,sage).

problem(fungus\_like,potato\_blight).

% Powdery mildew(fungal disease)

problem(powdery\_mildew,courgettes).

problem(powdery\_mildew,peas).

problem(powdery\_mildew,apple).

problem(powdery\_mildew,gooseberry).

problem(powdery\_mildew,hydrangea).

problem(powdery\_mildew,rose).

problem(powdery\_mildew,honeysuckle).

% Grey mold disease

problem(grey\_mold,strawberries).

problem(grey\_mold,grapes).

problem(grey\_mold,gooseberries).

problem(grey\_mold,blackberries).

problem(grey\_mold,tomato).

% Black Spots disease

problem(black\_spots,peony).

problem(black\_spots,macadamia).

problem(black\_spots,passionfruit).

```
problem(black_spots,mango).  
problem(black_spots,lychee).  
problem(black_spots,rose).
```

```
% Aphids disease  
problem(aphids,rose).  
problem(aphids,jasmine).  
problem(aphids,morning_glory).  
problem(aphids,olive_tree).  
problem(aphids,hibiscus).  
problem(aphids,mint).  
problem(aphids,parsley).  
problem(aphids,carnation).  
problem(aphids,lily).
```

```
% Rust disease  
problem(rust,daylilies).  
problem(rust,snapdragons).  
problem(rust,pines).  
problem(rust,rose).  
problem(rust,cznations).
```

```
% Verticillium Wilt disease  
problem(verticillium_wilt,maple_tree).  
problem(verticillium_wilt,barberry).  
problem(verticillium_wilt,lilac).  
problem(verticillium_wilt,linden).
```

% Aster Yellows disease

problem(aster\_yellows,zinnia).

problem(aster\_yellows,carrot).

problem(aster\_yellows,petunia).

problem(aster\_yellows,chrysanthemum).

problem(aster\_yellows,celery).

% Mosaic Virus disease

problem(mosaic\_virus,figs).

problem(mosaic\_virus,tomato).

problem(mosaic\_virus,celery).

problem(mosaic\_virus,cucumbers).

problem(mosaic\_virus,peppers).

% Snow Mold disease

problem(snow\_mold,cereals).

problem(snow\_mold,forage\_grasses).

problem(snow\_mold,turf\_grasses).

% Recommendations "Treatments" for the plants based on the type of

% diseases that a plant is prone to have them

% Fungus Like Disease treatments

recommendation(fungus\_like,

'1- Avoid watering the plants from above to help keep the leaves dry.

2- Maximize airflow between the plants by giving them plenty of space. Tie vines to a trellis or cane support to help keep them off the ground.

3- If possible, bring the plants into the greenhouse to help prevent them from catching blight and ruining your produce.

4- remove the infected plants to prevent the spread of the fungus.' ).

%Powdery Mildew disease treatments

recommendation(powdery\_mildew,'

1- Mulching, balanced feeding, and regular watering will help deter this unattractive disease.

2- On ornamental plants, spray the infected plant with Fungus Clear between April and September.

3- Prune out and dispose of infected shoots as soon as you see them, but don't compost them. Raking up and destroying fallen infected leaves in autumn will help reduce the spread of spores.' ).

%Grey Mold Disease Treatments

recommendation(grey\_mold,'

1- Improving the ventilation in a greenhouse should help reduce the risk of mold.

2- Prune off any moldy leaves, buds, or fruit as soon as you see it and burn them, and don't forget to clean your tools afterward.

3- Reduce

overcrowding of plants allow for better ventilation and reduce humidity to prevent mould establishing' ).

%Black Spots disease Treatments

recommendation(black\_spots,'

1- The fungus overwinters in diseased canes and leaves, so remove both before winter.

2- Keep foliage clean and dry by mulching beneath plants, positioning roses where the morning sun will quickly evaporate dew, and watering at the roots rather than wetting the foliage.

3- Consider planting varieties of roses that are resistant to black spots.

4- Spray the plants with a fungicide to prevent black spots.' ).

#### %Aphids Disease Treatments

recommendation(aphids, '

1- Biological Control: Introduce natural predators or attract beneficial insects.

2- Neem Oil: Disrupts aphid feeding and acts as a repellent.

Insecticidal Soaps: Break down aphid protective layers, causing dehydration.

3- Spraying with Water: Dislodge aphids with a strong water stream, focusing on leaf undersides.

4- Companion Planting: Plant species that repel aphids near susceptible crops.' ).

#### %Rust Disease Treatments

recommendation(rust, '

1- Purchases Fungicides and use it on the infected plant

2-Gather and destroy any infected plants to prevent the fungus from overwintering.

3- Pick or prune away any affected leaves as soon as you see them.' ).

#### % Verticillium Wilt Disease Treatments

```
recommendation(verticillium_wilt, '  
Unfortunately, there is no effective treatment for verticillium wilt.' ).
```

%Aster Yellows Disease Treatments

```
recommendation(aster_yellows, '  
Unfortunately, there is no effective treatment for aster yellows.' ).
```

%Mosaic Virus disease Treatments

```
recommendation(mosaic_virus, 'Once a plant is infected, there are no cures for viral diseases, such as  
the mosaic virus.' ).
```

%Snow Mold disease Treatments

```
recommendation(snow_mold, 'Gently take the affected areas of the lawn with a leaf rake.' ).
```

% Rules to identify the plant health issues

```
identify_problem(Plant, Issue) :-
```

```
    problem(Issue, Plant).
```

% Rules to provide a personalized recommendations (treatments) bases on

% the plant diseases

```
get_recommendation(Plant, Recommendation) :-
```

```
    identify_problem(Plant, Issue),
```

```
    recommendation(Issue, Recommendation).
```

% Rules to determine if a plant is considered an indoor or outdoor

% plant, base on the database of our system

%If a Plants is Indoor

is\_indoor\_plant(Plant) :-

    plant(Plant, indoor), !.

%If a Plants is Outdoor

is\_outdoor\_plant(Plant) :-

    plant(Plant, outdoor).

%If a Plants is both outdoor and indoor

is\_both\_plant(Plant) :-

    plant(Plant, both).

% Rule to find plants with a specific problem

plants\_with\_problem(Problem, Plants) :-

    setof(Plant, problem(Problem, Plant), Plants).

% Rule to find diseases for a specific plant

diseases\_for\_plant(Plant, Diseases) :-

    setof(Problem, problem(Problem, Plant), Diseases).

% Rules to assist users in improving plant care practices

assist(Plant) :-

    diseases\_for\_plant(Plant, Diseases),

    format('Plant: ~w~n', [Plant]),

    format('Diseases: ~w~n', [Diseases]).

```
% Main menu that will be displayed on the uses screen  
  
main_menu:-  
  
    write("),nl,  
  
    write('--- Welcome to PlantCare ---'), nl,  
  
    write(' A Plant Health Diagnosis Expert System'), nl,  
  
    write('Our goal is to create a comprehensive and efficient tool that uses expert knowledge to  
diagnose and identify plant health issues. '), nl,  
  
    write('Kindly select your choice from (1-5)'), nl,  
  
    write('1. Identify the plant health issue'), nl,  
  
    write('2. Get personalized recommendation'), nl,  
  
    write('3. Determine the plant location (indoor, outdoor)'), nl,  
  
    write('4. Identify the disease and all realted plants'), nl,  
  
    write('5. Exit'), nl.
```

```
% Based on the user input of the numbers running from (1-4), each number will display a certain  
execution.
```

```
% Based on the user input of (1) and the plant name, the system will  
% retrieve information from the database and present all the issues the  
% plant can face.
```

```
selected_choice(1) :-
```

```
    write('Enter the name of a plant: '>,
```

```
    read(Plant),
```

```
    assist(Plant),!.
```

```
% Based on the user input of (2) and the plant name, the system will  
% retrieve information from the database and present its recommendation  
% or "Treatments "
```

```
selected_choice(2) :-
```

```
    write('Kindly Enter The Plant Name: '),
    read(Plant),
    get_recommendation(Plant, Recommendation),
    format('Recommendation for ~w: ~w~n', [Plant, Recommendation]),!.
```

```
%Based on the user input of(3) and the plant name, the system will
% retrieve information from the database and present the type of the
% plant base on the location (indoor,outdoor).
```

```
selected_choice(3) :-
```

```
    write('Kindly Enter The Plant Name: '),
    read(Plant),
    (is_indoor_plant(Plant) ->
        format('~w is an indoor plant.~n', [Plant])
     ; is_outdoor_plant(Plant) ->
        format('~w is an outdoor plant.~n', [Plant])
     ; is_both_plant(Plant) ->
        format('~w is both indoor and outdoor plant.~n', [Plant])
     ;
        format('Location information not available for ~w.~n', [Plant])
    ), !.
```

```
% Based on the user input of(4) and the plant disease name, the Expert
% system will retrieve information from the database and present all
% plants that have it in commen.
```

```
selected_choice(4) :-  
    write('Enter the name of the plant disease: '),  
    read(Disease),  
    plants_with_problem(Disease, Plants),  
    format('Plants with the problem ~w: ~w~n', [Disease, Plants]),!.
```

%Based on the user input of(5), the expert system is exiting.

```
selected_choice(5) :-  
    write('The Expert System is Exiting... .') ,!.
```

%User enters a number outside the range of (1-5)

```
selected_choice(_) :-  
    write('Invalid choice. Please try again.'), nl ,!.
```

% To Start Running The Program

```
start :-  
    repeat,  
    main_menu,  
    read(Choice),  
    selected_choice(Choice),  
    Choice = 5,!.
```