International Journal of Academic Information Systems Research (IJAISR)
ISSN: 2000-002X
Vol. 3 Issue 3, March – 2019, Pages: 16-22

Spinach Expert System: Diseases and Symptoms

Mohammed N. Abu Al-qumboz, Samy S. Abu-Naser

Department of Information Technology,
Faculty of Engineering & Information Technology,
Al-Azhar University, Gaza, Palestine

Abstract: *The health benefits of spinach include skin care, improved eyesight, regulated blood pressure, stronger muscles, and prevention of age-related macular degeneration and hemophilia. It also helps with health conditions such as cataracts, atherosclerosis, heart attacks, and neurological disorders. It helps in bone mineralization and exerts anti-ulcerative and anti-cancerous benefits.*

So farmers should have taken care of this plant. In this research we developed an expert system capable of knowing the disease that plants the plant by selecting the symptoms that appear on the plant from the list of symptoms that appear to the farmer to avoid the propagator writing the symptoms wrongly. The expert system was developed using CLIPS language and has been experimented by farmers and has given satisfactory results.

Keywords: Spinach, Expert System, CLIPS

1. INTRODUCTION

Spinach is a superfood. It is loaded with tons of nutrients in a low-calorie package. Dark, leafy greens like spinach are important for skin, hair, and bone health. They also provide protein, iron, vitamins, and minerals.

The possible health benefits of consuming spinach include improving blood glucose control in people with diabetes, lowering the risk of cancer, and improving bone health, as well as supplying minerals and vitamins that can provide a range of different

Spinach has been used by various cultures throughout history, notably in Mediterranean, Middle-Eastern, and South-East-Asian cuisines. It can be incorporated quite easily into any diet, as it is cheap and easy to prepare [1].

Figure 1: The figure shows Spinach

Spinach belongs to the Chenopodiaceae family (also known as goosefoot), a family of nutritional powerhouses including beets, chard, and quinoa. It shares a similar taste profile with these two other vegetables; the bitterness of beet greens and the slightly salty flavor of chard. There are three different types of spinach generally available: savoy, semi-savoy, and smooth leaf [1].

2. ARCHITECTURE OF EXPERT SYSTEM

Expert Systems, also known as Knowledge-based Systems, Intelligent Agent Systems, or more generally as Knowledge Systems, are computer programs that exhibit a similar high level of intelligent performance as human experts. An expert system generally consists of four components: a knowledge base, the search or inference system, a knowledge acquisition system, and the user interface or communication system.

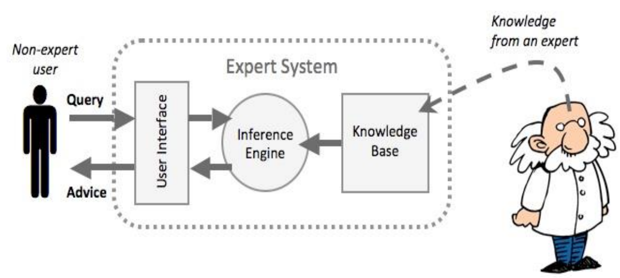

Figure 2: The figure shows Expert System component [11]

Knowledge systems solve difficult problems of the real world by performing inference processes on explicitly stated knowledge. The early rule-based systems of the 1970s, the subsequent model-based approaches of the late 1980s, and the newest knowledge systems with common sense, evolutionary knowledge growth and multiagency define three different generations of expert systems. Together these systems test one of the main hypothesis of the cognitive revolution of the sciences, namely that by virtue of being a physical symbol system, knowledge systems have the necessary and sufficient means for general intelligent action. There are several successful applications of knowledge systems in industry, business, medicine and science, as for example knowledge management systems and various components of e-commerce systems [4].

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In expert systems, there are two another major components: inference engine and knowledge base. The inference engine generates interpretations using the knowledge base. Rules are used as the representation for knowledge in the knowledge base and the interpretations by the inference engine are diagnoses, classifications or conclusions. High quality rules within the knowledge base are built by domain experts using the knowledge acquisition method. This method is the key to the success of expert systems as they are bound to the quality of acquired knowledge. However, knowledge acquisition is a difficult process within expert systems because domain experts usually provide incomplete, even incorrect, knowledge as they are unable to articulate it. This is called 'knowledge acquisition bottleneck' [3, 9].

3. Materials and Methods

The purpose of this expert system show in figure 3 is to identify the disease by selecting the symptoms shown on the plant from the list of symptoms available in the list of symptoms as shown in Figure 4

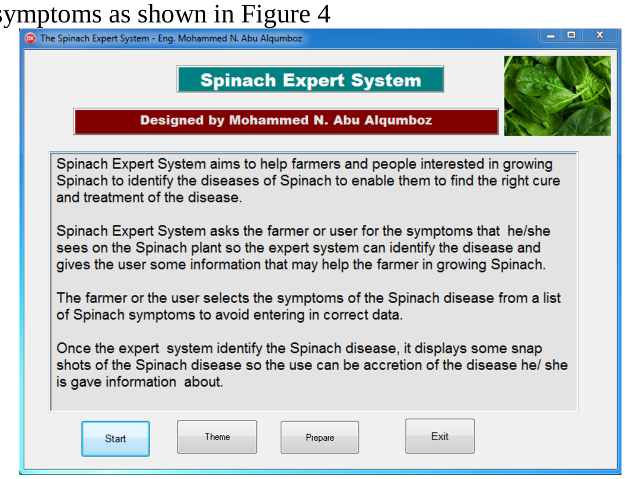

Figure 3: The figure shows spinach expert system

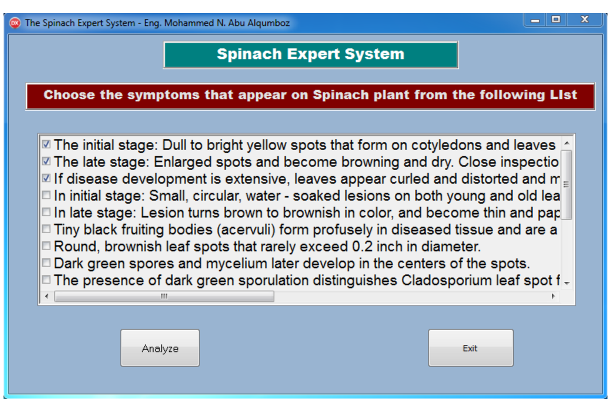

Figure 4: The figure shows a sample dialogue between the expert system and the user.

After analyzing the symptoms by the expert system, the result of the analysis is presented in Figure 5, showing the probability of survival and spread as well as the appropriate conditions for the disease

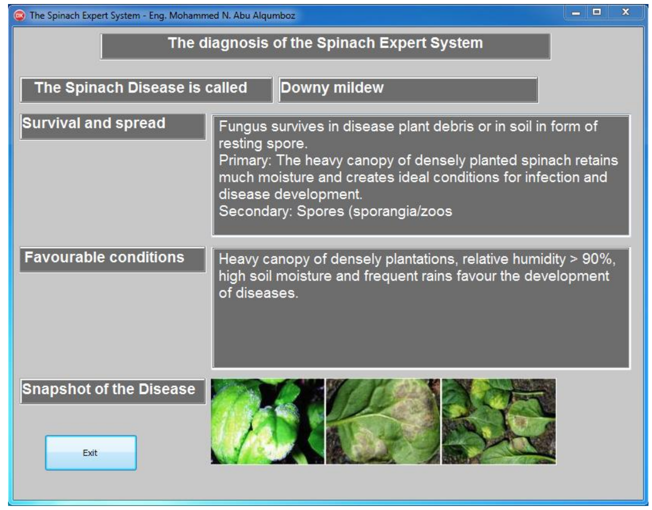

Figure 5: The figure shows how the users get the diagnosis and recommendation

4. Literature Review

There are many expert systems that are developed for diagnosing human problems like [37-42, 44-47, 49], plant and trees problem like: general plant [2], mango [10], Black pepper [11], banana [6, 43] onion [21], potato [35], Pineapple [7], watermelon [48] and other kinds of diseases. But there is no specialized expert system for the diagnosis of spinach diseases available free. The authors designed and developed an expert system to help farmers in diagnosing spinach diseases using CLIPS and Delphi languages.

5. Knowledge Representation

The main sources of the knowledge for this expert system are specializes websites for spinach diseases. The captured knowledge has been converted into CLIPS Knowledge base syntax (Facts, Rules and Functions) [10]:

5.1 Downy mildew

It is a disease of the foliage, caused by a fungus-like (Oomycete) organism. It is spread from plant to plant by airborne spores. It is a disease of wet weather as infection is favoured by prolonged leaf wetness.

Disease symptoms

- **The initial stage:** Dull to bright yellow spots that form on cotyledons and leaves of all ages.
- **The late stage:** Enlarged spots and become browning and dry. Close inspection of the underside of the leaf often reveals the purple growth of the fungus.
- If disease development is extensive, leaves appear curled and distorted and may take on a blighted effect as a result of numerous infection sites.

Survival and spread

- Fungus survives in disease plant debris or in soil in form of resting spore.
- **Primary:** The heavy canopy of densely planted spinach retains much moisture and creates ideal conditions for infection and disease development.
- **Secondary:** Spores (sporangia/zoospores) are dispersed in the air from plant to plant and field to field by winds and splashing water.

Favourable conditions

- Heavy canopy of densely plantations, relative humidity > 90%, high soil moisture and frequent rains favour the development of diseases.

Figure 6: The figure shows Downy mildew

5.2 Anthracnose

is a general term for a variety of diseases that affect plants in similar ways. **Anthracnose** is especially known for the damage that it can cause to trees. **Anthracnose** is caused by a fungus, and among vegetables, it attacks cucurbits.

Disease symptoms

- **In initial stage:** Small, circular, water - soaked lesions on both young and old leaves.
- **In late stage:** Lesion turns brown to brownish in color, and become thin and papery.
- Tiny black fruiting bodies (acervuli) form profusely in diseased tissue and are a characteristic feature of the disease.

Survival and spread

- Fungus survives in plant debris or soil.
- **Primary:** Seed borne inoculum and dormant mycelium in infected plant debris.
- **Secondary:** Spores are spread from plant – to - plants by splashing water from rains or sprinklers

Favourable conditions

- Relative humidity > 90%, High soil moisture and frequent rains favour the development of disease.

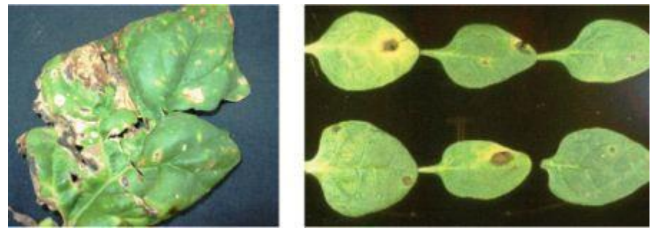

Figure 7: The figure shows Anthracnose

5.3 Cladosporium Leaf spot

It is caused by Cladosporium variabile is considered to be of minor importance in spinach crops, but can be severe in spinach seed production and has become a problem in high tunnels. It is also not known how long the fungus can survive on spinach residues in soil or in weed hosts.

Disease symptoms

- Round, brownish leaf spots that rarely exceed 0.2 inch in diameter.
- Dark green spores and mycelium later develop in the centers of the spots.
- The presence of dark green sporulation distinguishes Cladosporium leaf spot from anthracnose and Stemphylium leaf spot diseases, both of which also form circular lesions.

Survival and spread

- Pathogen survives in seeds and these seeds are source of primary inoculums. The secondary spread occurs by means of conidia.

Favourable conditions

- Heavy rain in spring favours the development of diseases.

Figure 8: The figure shows Cladosporium Leaf spot[

5.4 Stemphylium leaf spot

Stemphylium leaf spot on mature foliage in the field could be confused with initial symptoms of Cladosporium leaf spot or phytotoxic damage caused by pesticide sprays or fertilizer applications. Prior to 1997, the University of California Cooperative Extension Diagnostic Laboratory in Salinas had received samples of spinach having symptoms resembling those of Stemphylium leaf spot; however, because of the close resemblance to chemical burn, such samples were not further analyzed. It is possible, therefore, that Stemphylium leaf spot had occurred in California prior to 1997 but was misdiagnosed as chemical damage.

Disease symptoms

- **Initial stage:** Small (0.1 to 0.2 inch diameter), circular to oval, gray-green leaf spots.
- **Late stage:** Leaf spots enlarge, remain circular to oval in shape, and turn brownish in color. Older spots coalesce, dry up, and become papery in texture.
- Visual signs of fungal growth are generally absent from the spots; hence this symptoms is readily differentiated from foliar diseases in which purple growth (downy mildew), green spores (Cladosporium leaf spot), or acervuli (anthracnose) develop within circular lesions.
- Overall, symptoms resemble the brownish, circular spots caused by pesticide or fertilizer toxicity.

Survival and spread

- Fungus survives in seeds and infected seeds are the source of primary inoculums. Secondary infection occurs by means of conidia.

Favourable conditions

- High humidity and moisture conditions favour the development of disease.

Figure 9: The figure shows Stemphylium leaf spot

5.5 Damping off and root rot

Several fungi can cause decay of seeds and seedlings including species of rhizoctonia, fusarium and phytophthora. However, species of the soil fungus pythium are most often the culprit. **Damping off** typically occurs when old seed is planted in cold, wet soil and is further increased by poor soil drainage.

Disease symptoms

- Symptoms of damping-off and root rot consist of poor seed germination, pre-emergence death of seedlings, post emergence death of newly emerged seedlings, stunted plants, yellowed lower leaves, general poor growth, wilting, and eventual collapse and death of older plants.
- Roots of infected plants can appear water-soaked or brown to black in color. The upper taproot may be girdled by a necrotic lesion, or the tip of the taproot may be necrotic. In severe cases, nearly all roots may be girdled or rotted off.
- Severity is influenced by cultivar, soil texture, irrigation, and pathogen populations. Severe damping- off is associated with clay or poorly draining soils with a history of frequent spinach production. While all stages of spinach can be infected by root rot organisms, newly emerging plants and young seedlings are very susceptible.

Survival and spread

- The fungus survives in soil and inoculum present in the soil is source of primary infection. Secondary infection occurs by means of conidia through rain splash or wind.

Favourable conditions

- High humidity, high soil moisture, cloudiness and low temperatures below 24°C for few days are ideal for infection and development of disease.
- Crowded seedlings, dampness due to high rainfall, poor drainage and excess of soil solutes hamper plant growth and increase the pathogenic damping-off.

Figure 10: The figure shows Damping off and root rot

6. Limitation

The current expert system is specialized in the diagnosis only the following five spinach diseases: Downy mildew, Anthracnose, Cladosporium Leaf spot, Stemphylium leaf spot, Damping off and root rot

7. System Evaluation

This system offers an expert user interface and easy to use and after experimenting by me and a group of farmers in the trial of some of the symptoms we found that the system gives satisfactory results and farmers did not find it difficult to use the program because they can choose the symptoms from the list of symptoms without having to write.

8. Conclusion

In this paper we have introduced an expert system that helps farmers to detect spinach diseases by encountering a simple user showing the list of symptoms. The farmer should choose the symptoms that appear on the plant and then the system will analyze these symptoms and show the disease corresponding to those diseases based on the rules of the program Using CLIPS and Delphi languages.

9. Future Works

In the future, I seek to develop an expert system that can identify plant disease by taking a picture of the plant without having to write or choose the symptoms, analyze the image and show the plant diseases.

10. Source Code

```
(defrule disease1
(spinach-symptom 1 yes)
(spinach-symptom 2 yes)
(spinach-symptom 3 yes)
(not (spinach disease identified))
=>
(assert (spinach disease identified))
(printout fdatao "1"  crlf )
)
(defrule disease2
(spinach-symptom 4 yes)
(spinach-symptom 5 yes)
(spinach-symptom 6 yes)
(not (spinach disease identified))
=>
(assert (spinach disease identified))
(printout fdatao "2"  crlf )
)
(defrule disease3
(spinach-symptom 7 yes)
(spinach-symptom 8 yes)
(spinach-symptom 9 yes)
(not (spinach disease identified))
=>
(assert (spinach disease identified))
(printout fdatao "3"  crlf )
)
(defrule disease4
(spinach-symptom 10 yes)
(spinach-symptom 11 yes)
(spinach-symptom 12 yes)
(spinach-symptom 13 yes)
(not (spinach disease identified))
=>
(assert (spinach disease identified))
(printout fdatao "4"  crlf )
)
(defrule disease5
(spinach-symptom 14 yes)
(spinach-symptom 15 yes)
(spinach-symptom 16 yes)
(not (spinach disease identified))
=>
(assert (spinach disease identified))
(printout fdatao "5"  crlf )
)
(defrule endline
(spinach disease identified)
=>
  (close fdatao)
)
 (defrule readdata
  (declare (salience 1000))
  (initial-fact)
  ?fx <- (initial-fact)
=>
  (retract ?fx)
  (open "data.txt" fdata "r")
  (open "result.txt" fdatao "w")
  (bind ?symptom1 (read fdata))
  (bind ?symptom2 (read fdata))
  (bind ?symptom3 (read fdata))
  (bind ?symptom4 (read fdata))
  (bind ?symptom5 (read fdata))
  (bind ?symptom6 (read fdata))
  (bind ?symptom7 (read fdata))
  (assert
    (spinach-symptom ?symptom1 yes)
    (spinach-symptom ?symptom2 yes)
    (spinach-symptom ?symptom3 yes)
    (spinach-symptom ?symptom4 yes)
    (spinach-symptom ?symptom5 yes)
    (spinach-symptom ?symptom6 yes)
    (spinach-symptom ?symptom7 yes)
    )
   (close fdata)
)
```

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