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Knowledge Based System for Diagnosis and Management of Okra Diseases

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***Abstract*—**This work is related with the introduction of *KBSDMOD (*Knowledge Based System for Diagnosis and Management of Okra Diseases*). Okra / Lady Finger (Abelmoschus esculentus* L.*) is a very valuable and much likely vegetable for most the people in the World that is found all over the world. The Top five producing countries of Okra include; India 61.9%, Nigeria 22.2%, Sudan 3.2%, Mali 2.7% and Pakistan 1.3% and or exporting to countries like; Afghanistan, UAE, Iran and Malaysia. The World production of Okra is 8900434 tons and area under cultivation is 2157961 hectares. World rankin of Pakistan is 5th number and its share is 1.3 % in the World. The area under cultivation is 15529 hectare and production of okra is 118986 tonnes in Pakistan. Unfortunately, diseases are the main concern of Okra, resulting to low yield in Pakistan as compared to other Okra producing countries. The main objective of this research study is to diagnose diseases of Okra in a timely manner and give accurate management practices to reduce losses and boost productivity in Pakistan. In this research study, we proposed an Expert System named as KBSDMOD that will give consultation to users at no cost and to replace to much extent the rare human experts of the problem domain. This work was completed in various stages, like; the required knowledge of the problem domain being acquired from agriculture experts and existing literature, was extracted and modeled using Decision Tree, a knowledge-based system using ESTA (Expert System for Text Animation) was developed for consultation. Agricultural experts, different students and group of farmers took interest in testing and evaluating the proposed Expert System which was found interesting and useful for them as a result. The proposed Expert System is not only limited to Pakistan and Okra vegetable but can easily be extended to other countries as well as other fruits and vegetables with minor changes.*

Keywords—Diagnosing, Diagnosing Okra Diseases, Disease Management, Knowledge Modeling, Decision Tree, Knowledge Based System, ESTA & KBSDMOD**.**

1. INTRODUCTION

Vegetables production is becoming much popular among farmers in Pakistan. Some peoples cultivate vegetables for home purposes at small scale and use as fresh cooking vegetable but at some places vegetables are grown for marketing purposes at large scale in the country. Sometimes vegetable cultivators have a great opportunity to gain more profits than fruits cultivators within a short period of time. Orchard is a long-term business but vegetables cultivation is a short term and get more profits than the orchard. Vegetables are the basic necessity for human health. These vegetables provide Vitamins, Minerals, Salts, Sugars, Protein, Carbohydrate, Calcium and Water. Every vegetable is useful for human health and have its nutritional value along with other benefits. Therefore, we need to know about its management practices. Okra / Lady Finger (*Abelmoschus esculentus* L.) belong to family Malvaceae. Its origin is tropical Asia and Africa with the main region of cultivation and diversity of Okra in India, Srilanka, Pakistan, Nepal, and Bangladesh [1].

Okra is an important vegetable grown for its green tender fruits which are used as a vegetable in a variety of ways. It is rich in Vitamins, Calcium, Potassium and other minerals. It can very easily be fried and cooked with necessary ingredients. The tender fruiting can be cut into small pieces, boiled and served with soup. Matured fruit and stems containing crude fiber that are used in the paper industry [2].

According to [1] Okra has its nutritional value and they contain Energy 129 kJ (31 kcal), Carbohydrates 7.03g, Sugars 1.20g, Dietary fiber 3.2 g, Fat 0.10g, Protein 2.00g, Water 90.17g and Calcium 81 mg. Some of the salient features of the Okra is given as under:

- **Seed Rate:** About 20 kg seed/ha is required for summer season crop whereas 10 kg seed/ha is needed for rainy season crop.

- **Method of Sowing and Space:** The seed should be sown on ridges with a distance of 60 cm between rows and 15-30 cm between plants.
- **Irrigation:** There must be enough moisture in the soil to facilitate better germination. The crop should be irrigated at an interval of 5-6 days in summer and whenever required in rainy season.
- **Soil and Climate:** Okra can be successfully cultivated in well sandy loam soil with good drainage. For best yield, soil pH should range between 6.0 and 6.8. It is a warm season crop and is susceptible to frost.
- **Manuring and Fertilizing:** The land should be incorporated with well rotten farm yard manure @ 25 t/ha one month before bed preparation. Before sowing 25 kg each of phosphorus and potash and 25 kg of nitrogen per hectare should be thoroughly mixed in the soil. Another dose of 25 kg of nitrogen per hectare should be provided at the time of flowering and fruit setting.
- **Weed Control:** Four hoeing's at 3,6,9 and 12 weeks' interval are required to keep weeds under control and to get better pod yield.
- **Harvesting:** The tender young pods should be harvested every alternate day. This will promote fruit development and yield. Delay in harvesting will result in poor quality produce due to an increase in crude fiber.
- **Yield:** The yield of Okra varies from 8 to 10 t/ha. of green fruit during summer and 10-12 t/ha. in the rainy season.
The Okra plant has been shown through Fig 1 as below [3].

Fig. 1: Okra Plant and its Green Tender Fruit

2. DISEASES, SYMPTOMS, CAUSES AND MANAGEMENT OF OKRA DISEASES

Some common diseases of Okra with its symptoms, causes and management are given as below: [4]

2.1 CHAROCOAL ROT

- **Disease Symptoms:** Discoloration of stem at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerota (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease.
- **Cause:** Fungus
- **Comments:** Fungus had a wide host range and affects beans, tobacco, soybean, pigeon pea and many other crops; disease is primarily spread via microsclerota in the soil.
- **Management:** Rotate crop to non-host to reduce build-up of inoculum in the soil; avoid water stress to plants by irrigating when required.

Fig 5 shows the Charcoal Rot Disease as below [5].

Fig. 2: Charcoal Rot Disease of Okra

2.2 FUSARIUM WILT

- **Disease Symptoms:** Wilting of cotyledons and seedling leaves; cotyledons become chlorotic at the edges and then necrotic; older plants exhibit symptoms of wilting and leaf chlorosis; wilting is usually gradual but may be pronounced after heavy summer rain; if infection is severe plants become stunted and may be killed; vascular system of infected plants becomes discolored and can be seen by cutting the stem.
- **Cause:** Fungus
- **Comments:** Disease emergence is favored by warm temperatures; fungus may be introduced to field through infected seed or by contaminated equipment and human movement.
- **Management:** Use on certified, disease-free seed; plant varieties with higher resistance to the disease in areas with a history of Fusarium diseases; fumigating the soil may reduce disease incidence.

Fig 3 represents the Fusarium Wilt Disease of Okra as under [6].

Fig. 3: The Fusarium Wilt Disease of Okra

2.3 POWDERY MILDEW

- **Disease Symptoms:** Powdery white covering on leaves; patches may coalesce to cover entire plant; if plant is heavily infected leaves may roll upward and appear scorched.
- **Cause:** Fungus
- **Comments:** Fungus overwinters on plant debris or alternate host; disease emergence is favored by warm, dry weather with cool nights that result in dew formation.
- **Management:** Use overhead irrigation (washes fungus from leaves and reduces viability); plant crop as early as possible; applications of appropriate fungicides may be necessary to control the disease.

Fig 4 depicts the Powdery Mildew effects of Okra [7].

Fig. 4: Okra having the Powdery Mildew

2.4 SOUTHERN BLIGHT

- **Disease Symptoms:** Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat
- **Cause:** Fungus
- **Comments:** Fungus can survive in soil for long periods; disease emergence favored by high temperatures, high humidity and acidic soil; disease found mainly in tropical and subtropical regions.
- **Management:** Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line.

Fig 5 shows the Southern Blight Disease of Okra [8].

Fig. 5: Okra with Southern Blight Disease

2.5 ENATION LEAF CULRL DISEASE

- **Disease Symptoms:** On lower surface of leaves, we will see small pinhead enations. This enation become warty and rough in structure at later stage. Reduce in leaf size. The stem, lateral branches and leaf petioles become twisted along enation. Leaves appear thick and leathery. In severely infected plants the emerging leaves shows bold enations and curling. In addition, produce few deformed fruits.
- **Cause:** Virus
- **Comments:** White fly transmits the virus.
- **Management:** Remove the infected plant and burn them to avoid further spread of disease; Use yellow sticky traps to monitor whiteflies population; if the whiteflies infestation is more spray suitable insecticides.

Fig. 6 shows the Twisting of stem and leaf petiole of Okra [4].

Fig. 6: Twisting of stem and leaf petiole of Okra

Fig. 7: shows the Enation on infected leaves of Okra [4].

Fig. 7: Enation on infected leaves of Okra [4]

2.6 YELLOW VEIN MOSAIC DISEASE

- **Disease Symptoms:** The infected leaves show alternate patches of green and yellow. Veins become clear and chlorotic. With the progress of disease, the veins become conspicuous and both vein and vein lets become thick. In advance stage, the stems and leaf stalk become distorted. Fruits are yellowish green in color and small in size.
- **Cause:** Virus
- **Comments:** Transmitted by white fly *Bemisia tabaci*. It causes huge loss if disease occur at early stage of crop.
- **Management:** Use resistant cultivars. Sow disease free certified seeds. Roughing of infected plants. Follow crop rotation. Keep the field free from weeds. Control vector with suitable insecticides.

Figures 8 and 9 shows the Yellow vein mosaic disease on young seedling and the Yellow vein mosaic disease on mature plant of Okra respectively [4].

Fig. 8: The Yellow Vein Mosaic Disease on Young Seedling of Okra

Fig. 9: The Yellow Vein Mosaic Disease on Mature Plant of Okra

Fig. 10 shows the infected leaf of Yellow vein mosaic disease of Okra [4].

Fig. 10: The Yellow Vein Mosaic Disease of Okra

3. KNOWLEDGE BASED SYSTEM

The knowledge-based system are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise [9].

3.1 KNOWLEDGE BASED SYSTEM ARCHITECTURE

A knowledge-based system is a computer program that possesses or represents knowledge in a particular domain, has the capability of processing manipulating or reasoning with this knowledge with a view to solve a problem, giving some achieving or to achieve some specific goal [10].

The components of knowledge-based system include:

- **Knowledge Base:** The knowledge base is the collection of facts and rules, which describe all the knowledge about the problem domain.
- **Inference Engine:** The inference engine is the part of the system that chooses which facts and rules to apply when trying to solve the user's query.
- **User Interface:** The user interface is the part of the system, which takes in the user's query in a readable form and passes it to the inference engine. It then displays the results to the user [9]. See Fig 11 for detail.

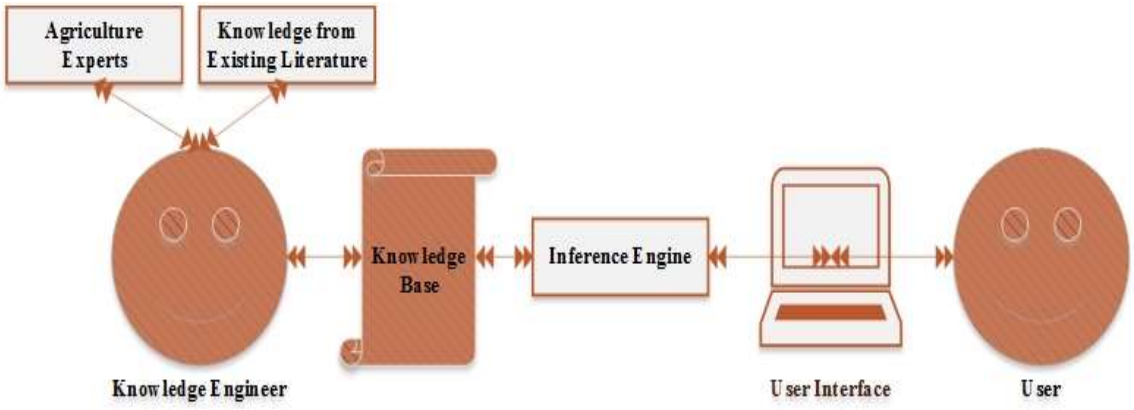

Fig. 11: The Architecture of Knowledge-Based System

4. LITERATURE REVIEW

Many knowledge-based systems are designed for the field of agriculture to diagnose the diseases and deficiencies of plants [12-32]. However, there is no specialized system for diagnosing Okra diseases available for free. Although many plant diseases have common symptoms. The proposed Ruled-based Expert System was developed specifically to help farmers in diagnosing and managing diseases of Okra.

Models are the best information carriers in terms of symbols or numbers rather than with actual tangible objects in an abstract way to depict the imaginations and thoughts of decision makers about their areas of domain [11].

The knowledge-based system, called AIES, enables users to determine the proper feasibility assessment for installation of agro-industries, which encompasses relationships among the many factors of the decision-making process across the domains of economic, financial, legal, technical, marketing and environmental feasibilities [12].

5. MATERIAL AND METHODS

The main sources of knowledge for knowledge-based system either from an expert in the field of agriculture or a website specialized in Okra diseases or existing literature, these sources are transferred to ESTA knowledge as facts and rules. There are currently a number of rules in the knowledge-based system that help to treat six diseases of Okra.

There are many approaches for representing acquired knowledge into the knowledge base but in this research study for developing the proposed system, we have chosen the rule-based knowledge representation scheme with simple IF and THEN rules. All knowledge about Okra diseases and its symptoms are represented into IF-THEN rules. These rules are normally in the form given below:

IF <antecedent> THEN <consequent>

For example: IF Symptom is ***Discoloration of stem at soil line*** THEN ***Disease is Charcoal Rot***

Diseases and its management are based on different symptoms of Okra diseases. For this study, the course of actions (knowledge) that are applied by plant experts have been identified, acquired and then the types of Okra diseases and their symptoms are modeled using decision tree. Most of crop diagnosis activities are performed by applying observation of the symptoms appeared on the parts of the plant. Therefore, in this research study, the symptoms of diseases associated with the types of diseases causing for the symptoms are modeled using decision tree and then developed a knowledge-based system for consultation.

5.1 DECISION TREE FOR DIAGNOSING OKRA DISEASES

Table. 1: Representation of Disease Symptoms with letter "S" for Decision Tree

Represented with "Letters"	Disease Symptoms
S1	Discoloration of stem at soil line; cankers on stem may spread upwards; leaves may wilt and drop from plant; numerous small black sclerota (fungal fruiting bodies) develop in affected tissues and can be used to diagnose the disease
S2	Wilting of cotyledons and seedling leaves; cotyledons become chlorotic at the edges and then necrotic; older plants exhibit symptoms of wilting and leaf chlorosis; wilting is usually gradual but may be pronounced after heavy summer rain; if infection is severe plants become stunted and may be killed; vascular system of infected plants becomes discolored and can be seen by cutting the stem
S3	Powdery white covering on leaves; patches may coalesce to cover entire plant; if plant is heavily infected leaves may roll upward and appear scorched
S4	Sudden wilting of leaves; yellowing foliage; browning stem above and below soil; browning branches; stem may be covered with fan-like mycelial mat
S5	On lower surface of leaves, we will see small pinhead enations. This enation become warty and rough in structure at later stage. Reduce in leaf size. The stem, lateral branches and leaf petioles become twisted along enation. Leaves appear thick and leathery. In severely infected plants the emerging leaves shows bold enations and curling. Moreover, produce few deformed fruits.
S6	The infected leaves shows alternate patches of green and yellow. Veins become clear and chlorotic. With the progress of disease, the veins become conspicuous and both vein and vein lets become thick. In

	advance stage, the stems and leaf stalk become distorted. Fruits are yellowish green in color and small in size

Table. 2: Representation of Diseases with letter "D" for Decision Tree

Represented with "Letters"	Diseases
D1	CHARCOAL ROT
D2	FUSARIUM
D3	POWDERY MILDEW
D4	SOUTHERN BLIGHT
D5	ENATION LEAF CULRL DISEASE
D6	YELLOW VEIN MOSAIC DISEASE

Table.3: Representation of Disease Management with letter "M" for Decision Tree

Represented with "Letters"	Diseases	Management
M1	CHARCOAL ROT	Rotate crop to non-host to reduce build-up of inoculum in the soil; avoid water stress to plants by irrigating when required.
M2	FUSARIUM	Use on certified, disease-free seed; plant varieties with higher resistance to the disease in areas with a history of Fusarium diseases; fumigating the soil may reduce disease incidence.
M3	POWDERY MILDEW	Use overhead irrigation (washes fungus from leaves and reduces viability); plant crop as early as possible; applications of appropriate fungicides may be necessary to control the disease.
M4	SOUTHERN BLIGHT	Remove infected plants; avoid overcrowding plants to promote air circulation; rotate crops with less susceptible plants; plow crop debris deep into soil; provide a barrier to infection by wrapping lower stems of plant with aluminum foil covering below ground portion of stem and 2-3 in above soil line
M5	ENATION LEAF CULRL DISEASE	Remove the infected plant and burn them to avoid further spread of disease; Use yellow sticky traps to monitor whiteflies population; if the whiteflies infestation is more spray suitable insecticides.
M6	YELLOW VEIN MOSAIC DISEASE	Use resistant cultivars. Sow disease free certified seeds. Roughing of infected plants. Follow crop rotation. Keep the field free from weeds. Control vector with suitable insecticides.

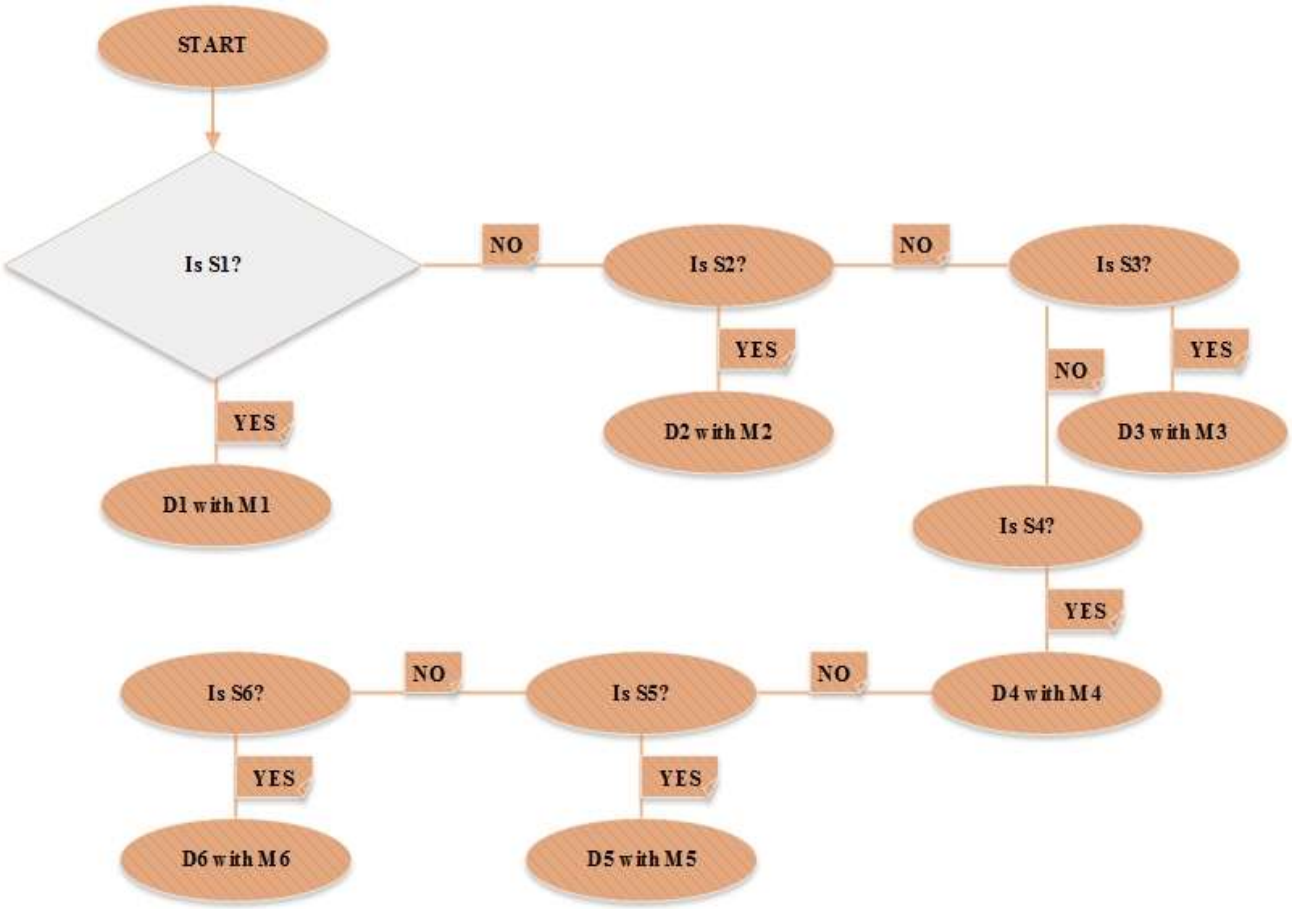

Fig. 12: The figure shows the Decision Tree for Diagnosing and managing Okra Diseases

5.2 CONSULTATION OF PROPOSED KNOWLEDGE BASED SYSTEM

The proposed knowledge based system performs diagnosis for six Okra diseases. The proposed knowledge-based system will ask the user to choose the correct Symptoms of Okra diseases in each screen as shown in Fig. 14, Fig. 15, and Fig. 16. At the end of the dialogue session, the proposed knowledge-based system provides the diagnosis, its causes and recommendation about management of disease to the user as shown in Fig. 17.

Figure. 13 represent the title of proposed knowledge-based system.

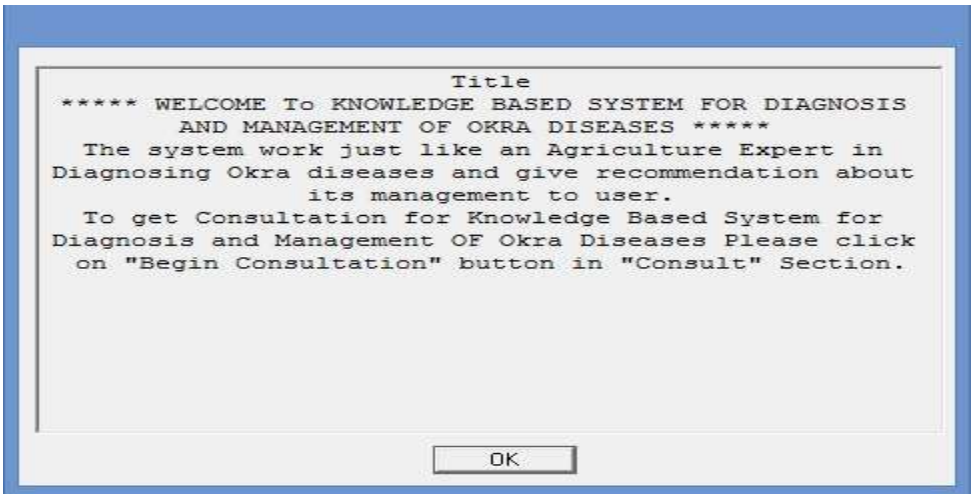

Fig. 13: Title of Proposed System

In Fig. 14: Shows the beginning of Consultation for diagnosing Okra diseases. It will ask questions from the users to diagnose diseases just like an agriculture expert.

Fig. 14: diagnosing POWDERY MILDEW disease of Okra

In Fig. 15: It describes the symptoms of POWDERY MILDEW disease of Okra.

Fig. 15: Symptoms of POWDERY MILDEW disease of Okra

In Fig. 16: It also describes the symptoms of POWDERY MILDEW disease of okra.

Fig. 16: Symptoms of POWDERY MILDEW disease of okra

In Fig. 17 shows the final results, the proposed Expert System,i.e., KBSDMOD, finally diagnosed disease of okra. The disease is POWDERY MILDEW. The system is not only limited to disease diagnosis it also provides information to user about its causes and management.

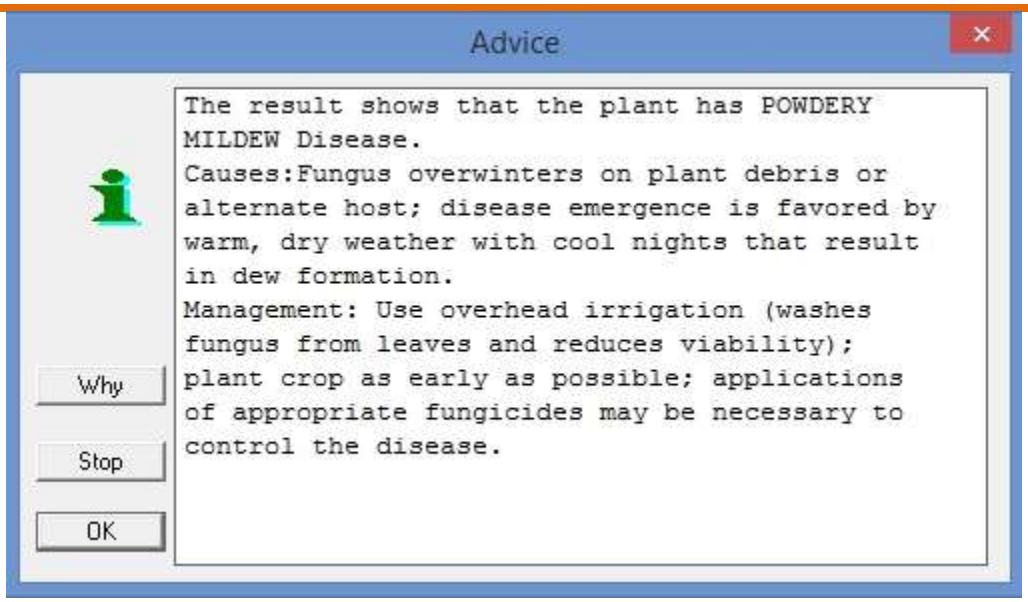

Fig. 17: Final Result of diagnosed disease

Similarly, the proposed system diagnoses all other diseases of Okra.

6. LIMITATIONS

The current proposed knowledge based system is specialized in the diagnosis of the six Okra diseases: Charcoal Rot, Fusarium Wilt, Powdery Mildew, Southern Blight, Enation Leaf Curl Disease, and Yellow Vein Mosaic Disease.

7. SYSTEM EVALUATION

As an initial evaluation, engineering students and other interested people in Okra cultivation, farmers, and agriculture instructors tested this KBSDMOD. They were asked to evaluate some of the following features of the proposed system:

- Is the knowledge-based system able to diagnose Okra diseases efficiently and accurately?
- Is the user screen informative enough in using the knowledge-based system?
- Is the knowledge-based system easy to use? etc.

8. CONCLUSUON AND FUTURE WORK

In this paper, a proposed knowledge-based system was introduced to assist agricultural students, researchers and farmers to treat Okra plants with six different Okra diseases. Agricultural students, researchers and farmers can get a faster and more accurate diagnosis than traditional diagnosis. This expert system does not require extensive training to use; it is easy to use and has an easy to use interface. It was developed using ESTA (Expert System Shell for Text Animation). In a preliminary evaluation of the proposed system, was introduced to Agriculture experts, agricultural students and group of farmers, and interested people in farming to use it and give us feedback about its content, ease of use, value, and simplicity. The result of the evaluation was very promising. In the future, more diseases and pests of Okra may be included in the knowledge base of proposed ES to reduce loses and enhance productivity in the area. In addition, this method can be used to develop knowledge-based system in other agricultural crops to reduce dependence on human experts to save time, efforts and money.

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