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أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

An Ontology-Based Approach for Diagnosing Date palm Diseases

طريقة لتشخيص أمراض نخيل التمر استناداً للأنطولوجيا

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An Ontology-Based Approach for Diagnosing Date Palm Diseases

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طريقة لتشخيص أمراض نخيل التمر استنادًا للأنطولوجيا

An Ontology-Based Approach for Diagnosing Date Palm Diseases

وبعد المناقشة العلنية التي تمت اليوم الاثنين 28 ذو الحجة 1436هـ، الموافق 2015/10/12م الساعة الثانية مساءً بمبنى طيبة، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق،،،

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Dedication

To my beloved father and mother

To my beloved brothers .. Ahmed and Mohammed

To my heart sisters.. Wessam and Anssam

To my sweet children... Tala, Anssam and Sohaeb

Acknowledgment

First, I thank Allah for giving me the strength and ability to complete this study.

I also thank my family: mother, father, brothers, and sisters; I also thank my wife for support and encourage working on this thesis.

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Mahmoud Abed El- Naser El-Askary
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Abstract

Date Palm is one of the oldest fruit trees in the world and is deeply rooted in the economics, history and culture in the Arab world. Because of its economic and social importance, date palm has a high research priority for further development of crop production and protection using the best approaches that modern science and technology can provide. Date palm trees as the rest of the fruit trees are exposed during their growth to many different pests that cause high economic damage to production. There are symptoms that appear on the plant which must be diagnosed quickly to make the right decision as a prevention. Pest control methods are the processes that lead to the reduction of pest's damage to plants by limiting the spread and reproduction.

In this research, we propose an approach that aids the development of a plant protection expert system for date palm. It is based on the ontology concept to diagnose the disease and suggest appropriate treatment by identifying anomalous observations on the parts of the tree. The approach consists of three inter-related components: knowledge base, reasoning engine and server side application. The knowledge base is built using OWL ontology and contains knowledge about date palm diseases and insect-pests, named for AgriDPalmOnto. The reasoning engine accepts user input queries and responses to data through the I/O interface and uses this dynamic information together with the static knowledge stored in the knowledge base. The web application works as an interface to the system where the user enters his queries and gets system feedback and answer. We evaluate the approach according to a human expert in plant diseases by comparing his diseases diagnoses to those of the system, system showed good accuracy in the results were 83.5% compared to documented scientific answers. The result is better than the agricultural expert's. We evaluate the ontology using Task-Based framework it indicate that the accuracy of using the AgriDPalmOnto is 100% and 96.7% when using evaluation method precision and recall. In addition, we use SPARQL queries to insure correct feedback from ontology.

Keywords: *Date Palm, Ontology, Semantic Web, Pest, Plant Protection, Expert System, AgriDPalmOnto.*

عنوان البحث:

طريقة لتشخيص أمراض نخيل التمر استناداً للأنطولوجيا

الملخص:

شجرة نخيل التمر هي واحدة من أقدم أشجار الفاكهة في العالم، ومتجذرة بعمق في الاقتصاد والتاريخ والثقافة في العالم العربي. وبسبب الأهمية الاقتصادية والاجتماعية فإن للنخيل أولوية عالية للعديد من الأبحاث لإنتاج المحاصيل وحمايتها وعملية التطوير باستخدام أفضل الأساليب التي يمكن أن تقدمها العلوم والتكنولوجيا الحديثة. تتعرض أشجار النخيل مثل بقية أشجار الفاكهة خلال نموها لكثير من الآفات المختلفة التي تسبب الضرر الاقتصادي المرتفع للإنتاج. وهناك أعراض تظهر على النبات ويجب تشخيصها بسرعة ومن ثم اتخاذ القرار الصحيح للوقاية من المرض. تعتبر طرق مكافحة الآفات هي العمليات التي تؤدي إلى الحد من أضرار الآفات على النباتات عن طريق الحد من انتشارها وتكاثرها.

في هذا البحث، نقترح طريقة تهدف إلى تطوير نظام خبير في وقاية نبات نخيل التمر. سيعتمد هذا النظام على مفهوم الأنطولوجيا لتشخيص المرض واقتراح العلاج المناسب من خلال تحديد الأعراض الظاهرة على أجزاء الشجرة. تتكون الطريقة من ثلاثة مكونات مترابطة وهي: قاعدة المعرفة Knowledge base، محرك المنطق Reasoning engine، والتطبيق Server side application، قاعدة المعرفة أنشئت من خلال استخدام لغة الانطولوجيا OWL والتي تحتوي على المعرفة حول أمراض نخيل التمر والحشرات والآفات التي تصيبها وسميت بـ AgriDPalmOnto. محرك المنطق يقبل استفسارات إدخال المستخدم والرد على الاسئلة من خلال واجهات الادخال والإخراج ويستخدم هذه المعلومات الحيوية سوية مع المعرفة الثابتة المخزنة في قاعدة المعرفة. تطبيق الويب يعمل كواجهة للنظام، حيث يقوم المستخدم بإدخال تساؤلاته ويحصل على رد النظام والإجابة. قمنا بتقييم الطريقة المقترحة وفقا لخبير زراعي في أمراض نبات نخيل التمر من خلال مقارنة أعراض مرض مع الموجودة في النظام، وأظهر النظام المقترح دقة جيدة في النتائج بنسبة 83.5% مقارنة مع الإجابات العلمية الموثقة. وكانت النتائج أفضل من إجابة الخبير الزراعي. قمنا بتقييم الأنطولوجيا باستخدام Task-Based framework فأشارت إلى دقة استخدام AgriDPalmOnto بنسبة 100% وبنسبة 96.7% عند استخدام معياري الدقة Precision والاسترجاع Recall. بالإضافة لما سبق لقد استخدمنا لغة الاستعلامات SPARQL للتأكيد على صحة المعلومات المسترجعة من الأنطولوجيا.

كلمات البحث: نخيل التمر، الأنطولوجيا ontology، الويب الدلالي، الآفات، وقاية النبات، النظام الخبير، نظام تشخيص أمراض نخيل التمر AgriDPalmOnto.

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List of Terminology

Pest	الآفة	Every living organism causing economic harm to humans or property.
Disease	المرض	Is a particular abnormal, pathological condition that affects part or all of an organism. It is often construed as a medical condition associated with specific symptoms and signs.
Etiology	علم أسباب المرض	The study of cause of disease; that phase of plant pathology which deals with the causal agent and its relations with the susceptible plant.
Pathogen	المسبب المرضي	Is anything that can produce disease. Typically the term is used to describe an infectious agent (colloquially known as a germ) - a microorganism, in the widest sense such as a virus, bacterium, prion, fungus or protozoan, that causes disease in its host. The host may be an animal, a plant, a fungus or even another microorganism.
Symptom	الأعراض	Signs and changes that appear on the plant or its parts as a result of its interaction with the pathogen. Or is a departure from normal function or feeling which is noticed by a patient, reflecting the presence of an unusual state, or of a disease.
Diagnosis of plant diseases	تشخيص أمراض النبات	The first and most important step of any control program (Integrated Management) is the correct definition of the lesion and the more accurate and early identification whenever possible control is more effective and less costly in the prevention or therapeutic procedures and less loss in yield.
Diagnosis	التشخيص	The process of determining pathogen and study any study of the Etiology rely on "hypothesis and answer", is art and procedure for the definition of the disease or pest through signs and symptoms.

List of Abbreviations

AgriDPalmOnto	Agriculture Date Palm Ontology
DL	Description Logic
OWL	Web Ontology Language
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
SPARQL	SPARQL Protocol and RDF Query Language
URIs	Uniform Resource Identifiers
W3C	World Wide Web Consortium
HTTP	Hyper Text Transfer Protocol

Chapter 1
Introduction

This chapter introduces the thesis by describing the domain and concepts of diagnosing date palm diseases as well as ontology development. We present the thesis problem, the research objectives, the importance of the research, the scope and limitations of the thesis work, the research methodology, resources, and tools.

1.1 Date Palm Diseases and Ontology Development

The date palm, mentioned more than any other fruit-bearing plant in the Qur'an and Bible, is a symbol often associated with Islam and Muslims. Allah says in the Holy Qur'an: "and from the palm trees - of its emerging fruit are clusters hanging low"," وَمِنَ النَّخْلِ مِن طَلْعِهَا قِنْوَانٌ دَانِيَةٌ" (Al-An'am, 99).

The date palm is one of the oldest fruit trees in the world. The number of the date palm trees is about 100 million worldwide, of which 62 million palms can be found in the Arab world [1,2]. The place of origin of the date palm is uncertain. Some claim that the date palm first originated in Babel, Iraq, while others believe that it originated in Dareen or Hofuf, Saudi Arabia [3].

Date palm is a major food source and income source for local populations in the Middle East and North Africa. It plays significant roles in the economy, society, and environment in these areas. The date palm is a perennial, the females of which usually begin to bearing dates within an average of five years from the time of planting the branch. The date palm reaches an age of about 150 years.

Palm tree is infected with many diseases, pests and insects that cause the production cut, and adversely affect the country's economy. Disease develops from an interaction between disease triangle components. Disease triangle [4] involves three major factors that contribute to the development of a plant disease: a susceptible host, a virulent pathogen, and a conductive environment. A plant disease results when these three factors occur simultaneously (Figure 1). If one or more of these factors do not occur, then the disease does not occur. The sick plant then gives evidence that something is wrong and the evidence of disease that we can see is called symptoms.

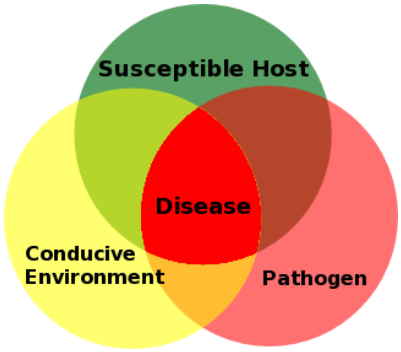

Figure 1.1: Plant disease triangle [4]

If someone, who has a plant problem asks two questions: What is the problem, and how do I solve it? These are hard questions for beginners and experts alike. Diagnosis is the process of determining the cause of a problem and is one of the most important aspects of a plant protection. It can be a long or short process depending on one's ability and the nature of the problem. Once the cause is known, an appropriate control strategy can be developed.

Plant pathologists take many different approaches to diagnosing plant disease problems. The broadest definition of plant disease includes anything that adversely affects plant health. This definition can include such factors as nutrient deficiencies, lawnmower damage, air pollution, and pathogens [5].

Control plant protection depend on proper identification of diseases [6] and of the causal diseases. Without proper identification of the disease and the disease-causing agent, disease control measures can be a waste of time and money and can lead to further plant losses. Proper disease diagnosis is therefore vital [7].

One of the most important things is using powers of observation to identify the symptoms that appear on the plant. Then we need to ask many questions related to the Etiology and symptoms phenomenon in order to eliminate or identify possible causes of the disease. We also need to consider various environmental and cultural factors. As a result of asking such questions and observations one may:

- Be able to identify a disease and disease-causing factor,
- Be able to narrow the problem down to several possibilities before being able to make a final diagnosis.
- Be completely baffled by the problem, or
- Recommend as to what should be done now.

The following are the basic steps in reaching a diagnosis [8]:

1. Identify the plant.
2. Examine the plant and note carefully any symptoms and signs.
3. Based on our knowledge of the plant and information from reference books, formulate a tentative diagnosis.
4. Attempt to confirm our tentative diagnosis. But if we are unable to confirm the initial tentative diagnosis with additional evidence, we formulate another tentative diagnosis.
5. Seek expert assistance. Sometimes additional laboratory work will be needed to confirm our diagnosis.

A software system based on computer-aided disease diagnosis is a very useful tool for farmers and researchers due to the following advantages [9]:

- Diagnosis more diseases in plant.
- A diagnosis recognized by the computer will reduce the farmer's level of uncertainty.

- It offers accuracy, consistence and a high confidence coefficient in results interpretation.
- It allows monitoring the health status of the plant during new treatment methods.
- The diagnosis identification time is significantly reduced.
- The diagnosis can be stored in a digital format.
- The quality and accessibility of services are increased.

At present, there are research efforts to develop ontology-based approaches by automated and semi-automated tools, in order to reduce development costs. However, it is very difficult to automatically or semi-automatically build ontology without having the appropriate knowledge base to start from.

Existence of agricultural specializations and full awareness with technological progress in a farmer is a very rare thing in our Arabic World. Human experts are not always available, may not be accessible to every farmer or if available consultation may be very expensive. The other complications are that the decisions in agriculture practice depend on large number of factors. Thus even for a human expert it becomes awkward to take all factors into consideration while making a decision. All such problems have resulted in the development and evolution of the concept of expert approach for diagnosing of date palm diseases.

Motivated by the existence of the gap in diagnosing date palm diseases in agriculture field in Arab World, we are going to develop a new ontology based approach for diagnosing date palm diseases. Such an approach would be an important contribution and a useful resource in the Arabic world agricultural knowledge base. In addition to that, it is reasonable to expect that the approach results in criteria and guidelines which may considerably facilitate the construction of other well-structured ontologies for a related issue in the broader agricultural domain. An ontology based approach is part of the semantic web.

The Semantic Web [10] "*transforms the Web by providing machine understandable and meaningful descriptions of Web resources*". Making the Web content machine understandable, allowing agents and applications to access a variety of heterogeneous resources, processing and integrating the content, and producing added value for the user. The semantic web [11] adds structured meaning and organization to the navigational data of the current web, based on formalized ontologies and controlled vocabularies with semantic links to each other.

Ontologies are a semantic web concept that can be used in many applications like information retrieval systems and decision-support systems [12]. Based on these applications, ontologies can also be helpful in the plant disease diagnosis based on observations.

One aim for the development of ontology is to share a common understanding of the structure of information among people or software agents. Another aim is to enable reuse of domain knowledge and to make explicit assumptions about a domain that are normally implied [13].

We design a domain-dependent ontology for date palm and its diseases that would aid in the process of diagnoses. We follow ontology development processes [13] for designing the ontology, which is based on Arabic language into a set of equivalent classes, properties, and relationships. The ontology is the core of an approach the diagnose diseases of the date palm, by identifying farmers or user's country, symptoms and abnormal plant part. The proposed approach will contain three basic modules namely; the diagnoses module, the pathogenesis stage module and the treatment recommendation module.

1.2 Statement of the Problem

Date palms are an important fruit crop in the Arab world for their economic and social value. But they are exposed to various diseases and pests. Although traditional approach to diagnoses are still widely used, they need additional expert tools alongside them.

The problem of this research is divided into two parts:

1- The lack of formal knowledge base for date palm diseases in the Arab World necessitates the development of appropriate domain ontology.
2- How to develop an efficient ontology-based approach for diagnosing date palm diseases based on the symptoms observed on the plant.

1.3 Objectives

- Main Objective

The main objective of this research is to develop an efficient approach based on a domain ontology to diagnose the diseases of date palm and speed up the acquisition of related knowledge.

- Specific Objectives

The specific objectives of this research are:

- To collect data about the domain of diagnosing the diseases of the date palm.
- To build the ontology and the knowledge base for date palm and its diseases.
- To develop the approach for date palm diseases diagnosis where the ontology is the focus.
- To perform the required date palm diseases diagnoses experiments on the approach based on knowledge base.

- To evaluate the approach including the ontology based on the experimental results for accuracy in the process of diagnoses.

1.4 Importance of the Research

- A conference on date palm pests in United Arab Emirates held in 2012 [14] recommended developing an Arabic expert system to date palms, and Arabic program to manage pest's date palm, this research aims to achieve these recommendations.
- The importance of the thesis lies on the danger of the diseases on the plant, and there is a great need to diagnose and determine appropriate treatment.
- The approach is expected to facilitate the science of disease diagnosis for agricultural engineers, agricultural guiders, farmers and researchers who are specialists and non-specialists.
- The use of ontology in diagnosing plant diseases can be the basis for future cooperation with the systems in the field of agriculture and plants.
- Accurate results are expected from the proposed approach in determining the cause of diseases, which saves time and effort.
- The developed ontology can be used as a basis for other applications, since there are some elements of common diseases with other plants.
- Support Arabic content through developing of Arabic ontology in the field of Arabic semantic web.

1.5 Scope and Limitations of the Research

- There are many different crop varieties in the Arab world, but because of the importance of the date palm in the economy, we concentrate on date palm trees and their diseases.
- There are different elements to identify plant diseases [4] such as identify the plant species, observation, accurate information, sample collection, identification of cause, confirmation of cause and recommendations. We focus mainly on disease diagnoses by symptoms observation.
- We use ontology processing methods that can apply the constructed proposed ontology because an important role of ontology is to serve as schemata or ‘intelligent’ view over information resources. Thus they can be used for indexing, querying, and reference purposes over non-ontological datasets and systems. .
- The ontology covers date palm diseases diagnoses. So the scope is not to cover date palm production, pre and post harvesting and date palm processing and is not related with economy, marketing, farm machinery and other un-related scope of subject.
- We deal with the diseases that show obvious symptoms and widely spread in the Arab world.

- We focus on diseases with chemical treatment because of chemical danger on the plant.

1.6 Methodology

To accomplish the objectives of the research, the following methodology is followed:

1. **Research and survey**: it includes a review of recent literature related to the thesis research problem especially in the field of disease diagnosis for plants [15]. Upon analyzing the existing methods, we can formulate a thorough understanding of develop its solution the problem and then
2. **Data collection:** We collect several date palm diseases in the Arab world related to identify the symptoms, etiology, diagnosis and treatment of each disease [63~72].
3. **Building the Ontology and the knowledge base:** in this phase to build the ontology, we follow ontology building processes such as [16] and [17] using tools such as, OWL-API, DL-Query, and Protégé 5.0 [18]. This includes the following tasks:

    A. Determine the domain and scope of the ontology.
    B. Consider reusing existing date palm ontology and extend it as an option.
    C. Enumerate the important terms in the ontology.
    D. Define the classes and the class hierarchy (taxonomy).
    E. Define the properties of classes (slots).
    F. Define the facets of the slots (Value type, Allowed values, Cardinality).
    G. Create instances of date palm diseases, pests, insect etc. as a knowledge base.
    H. Use a reasoner to get new knowledge for date palm diseases.
    I. Use some SPARQL to perform quires on the ontology that ensure the correct building of ontology and check whether it returns what we want?
4. **Build the approach:** we develop the approach using programming language such as JAVA and related APIs and tools for example JENA and then connect it with the built knowledge base.
5. **Test the approach:** to test the proposed approach by queries and results using a human expert and using SPARQL queries.
6. **Results and discussions:** in this stage we analyze the obtained results and evaluate the accuracy in disease diagnosis and compare with results obtained from the human expert.

1.7 Thesis Structure

The thesis consists of seven chapters organized around the objectives of the research.

- **Chapter 1** (Introduction): gives a short introduction on the diagnosing date palm diseases, ontology development , and the thesis problem and objectives.
- **Chapter 2** (Related Work): presents related works on ontology and knowledge retrieval, diseases diagnoses based on ontology, Arabic ontology and decision support.
- **Chapter 3** (Theoretical and Technical Foundation): describes the theoretical and technical foundation needed for the thesis work, date palm tree, diseases, diagnosis of diseases, pathogen, symptoms, treatment , ontology concepts, and web application.
- **Chapter 4** (AgriDPalmOnto Development): describes the development of the date palm ontology with the knowledge base and its evaluation.
- **Chapter 5** (AgriDPalmOnto Approach): presents the ontology based approach realized as a web application for diagnosing the date palm diseases.
- **Chapter 6** (AgriDPalmOnto Implementation): presents the approach and ontology implementation.
- **Chapter 7** (Experimentation and Evaluation): presents an evaluation of AgriDPalmOnto system by conduct a number of experiment on the system.
- **Chapter 8** (Conclusions and Future work): presents the conclusions and the possible future works.

1.8 Summary

In this chapter, we have introduced the thesis by describing the diagnosis of date palm diseases and ontology development. It is divided into eight sections. In the first section, we introduced the diagnosing date palm diseases and ontology concept its importance in the diagnosis process. In the second section, we stated the research problem and the possibility of using ontology in developing an efficient approach for diagnosing date palm diseases based on the symptoms observed on the plant. In the third section, we explained the main objective of this research which is to build a system based on ontology to diagnosing date palm diseases. In the fourth section, we explained the importance of this research; the most important is a conference on date palm pests in United Arab Emirates had in 2012 and recommended developing an Arabic expert system to date palms and Arabic program to manage pest's date palm. In the fifth section, we stated the scope and limitation of this research. The limitation is that there different elements to identify plant diseases, and we deal with the diseases that show obvious symptoms and widely spread in the Arab world**.** In the sixth section, we presented the methodology to be followed in this research including the method of building ontology, phases of building the approach, and the evaluation methods in terms of accuracy. In the last section, we explained how the thesis is organized and structured.

Chapter 2
Related Work

In this chapter, we study different related works. They are introduced and analyzed with respect to the research problem to show how far these works address the requirements of our research problem. Parts of the related works can be a basis for solving the research problem. They focus on disease diagnosis and ontology, plant ontology and retrieval knowledge, disease diagnosis, ontology development, Arabic ontology and decision support.

2.1 Ontology and Knowledge Retrieval

X. Jinhui et. al. [19] propose a system of agriculture as online service (AOS). AOS provides a common portal for ontology retrieval, which would benefit the agricultural knowledge management and other semantic applications. They build ontology farming system procedures that are multi-linguistic, indicating a scenario using the administrative and operational support. The AOS strive to increase the efficiency and consistency with which multilingual agricultural resources are described and associated together; increase functionality and relevance in accessing these resources; and provide a framework for sharing common descriptions, definitions and relations within the agricultural community.

AOS is in line with our research in the use of ontology to link concepts, and helps to understand the departments of agriculture. We are linked in this work by building ontology in same domain but we disagree with specializes in diseases of date palm. The AOS is limited with the general concepts of agriculture.

P. Sherimon et. al. [20] build ontology for date palm and dates used to exchange information and share knowledge and common understanding of the structure of information among people and software agents. It is not a comprehensible ontology. There are two main categories in the taxonomy such as date palm and dates. In the category of date palm, its products and species are described. It can be used to build a larger ontology. The ontology is limited to the concepts and the names of the date palm and does not address the date palm disease. The difference from our research is that in our case, we intend to develop a more comprehensive ontology that would also include date palm diseases. It is not possible to use it a basis for the comparison with our ontology because we rely on date palm diseases are not related concepts used by these ontology (such type palm and products).

J. Zhai and K. Zhou [21]build an ontology-based information retrieval system, which depends on the sport ontology and SPARQL query language for retrieving documents that build the sports ontology which has the character of wide-cover and small information granularity and search system for sports information. Sports ontology model and information retrieval system which realizes intelligent information retrieval through semantic relationship between sports concepts. They employ semantic relations

between the ontology concepts, according to the relations, "a synonym of", "kind of" and "part of" between mathematical concepts. The further research is to achieve intelligent fuzzy retrieval of sport information through fuzzy ontology. The operation of ontology-based information retrieval contain multiple steps start by building a domain ontology, collect a dataset from the sources to annotate dataset using an ontology, the search engine used to complete semantic matching of retrieval conditions over ontology reasoning to find out the correct dataset, the last step cover the results which back to the user. The limitations of the system that it is difficult for normal user to make query depends on SPARQL query, but this mean we need professional users.

The above works show growing interest and in adopting to building ontologies to improve knowledge retrieval and speed up acquisition of knowledge. This is very helpful in the stage of development our proposed ontology.

2.2 Disease Diagnosis and Ontology Development

A. Rafea [22] develop the Barley expert system for plant protection, the goal is to speed up the acquisition of knowledge and enable human experts to cooperate with the knowledge engineer through using the tool and represent the knowledge in XML which is a standard data language to facilitate knowledge verification and future upgrading. The plant protection knowledge has been modeled into four modules: variety selection, cultural practices, pest identification, and pest control. The tasks of the four modules are built-in in the tool. The tool also allows the user to choose the input and outputs of thee system as it has a presentation layer. It has an administration component that enables the tool administrator to manage registrations of different types of users (administrator, expert, end user), manage the addition /deletion of expert systems projects, and assign users to projects. The tool contains also an ontology editor to help the user in building the plant protection ontology. In our research we develop enhanced date palm ontology with diagnosis with additional operations such as support for image and search.

W. Wang et. al. [23] develop an system ontology based with diseases and pests of rice with knowledge on prevention diagnostics. They build a knowledge base with the ontology of the tongue. Their system can be used in the practice of production and sheds light on the disease and pest diagnostics, telemetry and prevention. Their system consists of five modules according to the characteristics of diagnosis and actual application requirements the user logging module, disease and pest diagnosis and treatment module, query module, prediction module and assistance module. My research is affected by this work through how agriculture-related information is transformed to knowledge acquisition and offering of proper knowledge services.

H. Almutair and S. El-Masri [24] propose a new design for a knowledge base framework for a patient diagnosis based on clinical practice guidelines(CPG). This framework is a general base, which can be used with more specialization for quickly modeling a specific clinical practice guideline. The methodology content on four steps.

The first step of this methodology is to choose an appropriate clinical practice guidelines resource as the base of this research. The second step and as the domain of the research, 30 different diseases has been chosen from different human organs and have been visualized in tables based on their symptoms, signs, and diagnosis procedures. The third step is capturing and modeling the common symptoms and signs among these 30 different diseases and with the help of the differential diagnosis that will go out at the end, the patient will be successfully diagnosed. The fourth and the last step in this methodology is the transformation of these models into a knowledge base ontology framework for patient diagnosis based on clinical practice guidelines by using Protégé. It has been clear that the existing clinical practice guidelines emphasize on one disease or one medical problem. Therefore, there is an urgent need to fill this huge gap and to build such CPG or more precisely a general framework that can fit at least 75% of all steps needed in diagnosis for most CPGs. The framework success of save time and work.

F. Alamu et. al. [25] develop semantic medical ontology which focuses entirely on malaria diseases. because, the type of access provided by some of the existing medical ontology is a somewhat cumbersome process and the data that might be provided at the end is often not comprehensive and concise. The methodology used for this project work involve the gathering of adequate and correct information on malaria from recognized bodies i.e. the parasites, the mode of treatment, Malaria type, symptoms, etc., developing an ontology model from the information given and providing a means of remote or online access for individuals or groups that require information that is well represented.

In this research, an ontology model that is completely devoted to the malaria parasite along with the establishment of a semantic website that enables a less cumbersome mode of access to relevant information gathered on malaria was developed. The model adopted consisted of an ontology created using the Protégé-OWL software, a database created for the project using the appropriate tool (XAMP), a procedure for accessing the data contained in the database and an interface for interaction with the system. The interaction with the system is in form of queries, after the user has successfully logged on. A comprehensive malaria disease database has been implemented to provide useful structured information for user. Performance test result shows that the built ontology system is user friendly, has enough concise information, and recommended to be used as reference for malaria disease management.

M. Thirugnanam et. al. [26] develop an approach to create disease information and symptoms with the help of ontology. The ontology consists of diseases and their relationship with symptoms and SWRL rules (Semantic Web Rule Language) designed to predict diseases. The ontology contains two stages. The first stage define the class hierarchy and define the object and data properties. The second stage executes rules which extract the disease details with symptoms based on the rule specified. Finally the inferred axioms are reflected in the ontology. This work points out the importance of

creating a disease information. The limitations of the approach that it is not showing the practical application of the ontology used، also the architecture not clear.

M. Alfonse et. al. [27] propose an ontology based diagnostic methodology for cancer diseases. Because cancer is one of the most dangerous diseases known to human, they discuss the technical aspects of some of the ontology-based medical systems for cancer diseases. The proposed methodology contains three basic modules namely; the diagnostic module, the staging module and the treatment recommendation module. This methodology can be applied to help patients, students and doctors to decide what cancer type the patient has, what is the stage of the cancer and how it can be treated. In our research there are similarities in the methodology in terms of building the system like diagnosis module and treatment recommendation, but the field is different with additions in the implementation steps.

L. Schriml et. al. [28] develop a disease ontology (DO) database that represents a comprehensive knowledge base of 8043 inherited, developmental and acquired human diseases. The description of this ontology includes semantic integration activities, data updates and development directions. They design a web browser for ontology to enhance speed, efficiency and durability through the use of the graph database and provide a framework for extracting data, logic and reasoning to enable exploration of the disease and genes of medical data for continuous research and discovery of novel based on common representation of the disease. It creates a single structure for the classification of diseases that unite the representation of disease among the many and varied terminology and vocabulary in relational ontology that allows reasoning and logic relations between terms and concepts of the disease and is optimized towards notation disease. The ontology database doesn't cover the entire contents of diseases and the tools used in the method are unclear.

The above works show a growing interest in studying the subject of diagnosing plant and human diseases such as barley, rice, malaria and cancer. We are going to form a new ontology based on diagnosing date palm diseases.

2.3 Arabic Ontology and Decision Support

S. Zaidi and M. Laskri [29] propos a method of query expansion based on an ontology in the legal domain in Arabic language. It is a web-based multilingual tool. It aims to improve the precision and recall of the search. They describe the manual construction of the ontology and the way it is edited using Protégé. The process of search for Arabic documents uses a query expansion. In addition to finding relevant documents in Arabic, the retrieval process is further enriched by enabling the user to translate the query into another language. A set of query words is used to enable the machine translation of the query from Arabic into English and French, they use WordNet to extend the translated query. The limitations of the method it not clear how the process of search execute.

R. Baraka and Y. Dalloul [30] design a domain-dependent ontology, called Hadith Isnad Ontology, for Isnad judgment in the Hadith domain. It structures Hadith concepts into a set of equivalent classes, properties, and relationships. The ontology is evaluated through Hadith examples to show that indeed the ontology represents all necessary and relevant knowledge about Hadith. The evaluation of ontology is done through DL-queries to show and test its usability. The developed ontology is considered as the basic building block in the development of a complete ontology-based Isnad judgment system.

L. Al-Safadi et. al.[31] propose a model for representing Arabic knowledge in the computer technology domain using ontologies based search and retrieval of Arabic blogs on the web. The model starts by elicitation users information needs. ontologies will play a major role in supporting information search and retrieval processes of Arabic blogs on the web. they propose a model for designing the ontology which is based on structuring the Arabic language into a set of equivalent classes, properties and relationships. they analyzed the Arabic language on the web and investigated the existing Arabic support offered by semantic web applications and research. The analysis showed weak support for traditional Arabic language and almost no support for modern Arabic language, which is becoming today's blogs language. Thus, the need for developing domain-based ontologies for combining traditional Arabic and modern Arabic is crucial. the limitation that they focus in this work is to implement the Arabic ontology only. We benefited from this work how to build ontology and how query from ontology. Our work shared with this work in the use of ontology as a basis for information retrieval semantically.

The above works show growing interest in Arab and Islamic researchers to build Arabic ontologies to increase the Arabic content on the semantic web. This is very helpful in the stage of development our proposed ontology.

2.4 Summary

We presented a number of related work in ontology, knowledge retrieval, disease diagnosis, ontology development, Arabic ontology and decision support.

We can conclude that these related works touches the idea discussed in terms of the use of ontology, but we will focus on the date palm. Additionally these works lack logical semantics rules that can help in reasoning. We construct an integrated ontology that includes data and images and supports reasoning-based querying.

Chapter 3
Theoretical and Technical Foundations

In this chapter, the fundamental concepts and technical knowledge which represent the basis for conducting and understanding of the thesis work are presented. Basic information on major diseases and pests of the date palm are presented, followed by semantic web, ontology basics and design ontology related languages and technologies such as RDF, RDFS, OWL, querying and reasoning.

3.1 Date Palm

Phoenix dactylifera is the Latin term for the Greek word that means "date palm". Date palm is one of the most important fruit trees growing in the Arabian world and some neighboring Country and represents a good economic crop for many farmers. Palm diseases are among the major factors that affect the plant. New accumulating data on date palm diseases have appeared during the last few years. To compensate the lack in sources of information about date palm diseases in Arabic world. With the need for a computerized system that supports diagnostic accuracy and speed our thesis is an attempt to provide an update in information on the most important diseases that have been reported on date palm in Arabic world and provide a new approach for diagnosing diseases.

Date palms are grown in more than 40 Country. The Arab world has more than 84 million date palm trees, 70 million of which are in Iraq, UAE, Saudi Arabia, Egypt, Syria, Sudan, Yemen, Bahrain, Oman, Libya, Tunisia, Morocco and Algeria [32]. The Arab world is the main producer and exporter of dates in the world. Out of the approximate total of 120 million date palm trees, around 70% are found in Arab Country. Table 3.1 shows statistical and productivity numbers of date palm in the Arab Country from the years 2010 up to the year 2012.

Date palm, mentioned more than any other fruit-bearing plant in the Qur'an, is a symbol often associated with Islam and Muslims. Throughout the month of Ramadan, dates are a common ingredient in the Muslim diet. It is a tall evergreen and consists of both male and female trees (called dioeciously). Only the female trees produce fruit, but one male tree can produce enough pollen to pollinate 40-50 female trees [33].

Date palm has a range of uses. High-energy date fruits have been placed high on the diets of the health conscious. Though the fruit still has untapped potential in the food industry, it also lends itself to countless other uses.

Table 3.1: Statistical productivity date palms in the Arab world until the year 2012[32]

Country	2012			2011			2010			متوسط الإنتاج للفترة 2009-2005	الدولة
	الانتاج	الاشجار المثمرة	المساحة المثمرة	الانتاج	الاشجار المثمرة	المساحة المثمرة	الانتاج	الاشجار المثمرة	المساحة المثمرة		
	Production	Fruiting Trees	Area	Production	Fruiting Trees	Area	Production	Fruiting Trees	Area	Average Production	
Jordan	46.43	315.95	1.97	11.21	234.05	1.45	11.20	232.62	1.47	5.89	الأردن
Emirates	900.00	16342.19	200.00	900.00	16342.19	200.00	825.30	16342.19	197.40	757.88	الأمارات
Bahrain	15.00	376.7	1.65	14.59	376.70	1.61	14.00	376.70	1.60	13.57	البحرين
Tunisia	190.00		52.50	180.00		51.00	174.00			135.00	تونس
Algeria	789.36	13791.91	0.00	724.89	12983.00	0.00	644.74	12355.00	0.00	537.77	الجزائر
Saudi Arabia	1031.00	-	156	1008.00	-	156.00	991.50	-	171.99	981.52	السعودية
Sudan	437.80	-	36.42	433.50	-	36.41	431.00	-	36.20	354.70	السودان
Syria	3.99	68.6	0.11	4.01	68.10	0.11	4.37	110.60	0.16	3.70	سوريا
Iraq	655.00	9698	123.23	619.00	9644.00	123.23	567.00	9276.00	123.00	451.80	العراق
Oman	262.00	7500	31.09	268.01	7500.00	31.09	276.40	7500.00	31.10	258.02	عمان
Palestine	0.00	0	0.71	1.24	113.04	0.58	2.41	83.91	0.48	2.92	فلسطين
Qatar	20.70	431.12	2.37	20.70	431.12	2.37	21.49	447.48	2.47	20.75	قطر
Kuwait	34.60	312.21	5.00	33.56	312.21	5.10	16.70	312.21	1.50	15.72	الكويت
Libya	170.00	2100	32.00	165.95	2100.00	30.06	161.00	2100.00	30.00	152.02	ليبيا
Egypt	1400.07	12535	38.50	1373.57	12262.00	41.65	1352.95	12177.00	41.94	1279.74	مصر
Morocco	113.1	4954.126	71.2	117.8	5160	43	119.4	4800	41	68.62	المغرب
Mauritania	22	600	8.78	21.44	600.00	8.64	19.9	600.00	8.30	11.68	موريتانيا
Yemen	54.90	4646	9.80	55.80	4669.00	9.90	57.90	4718.00	11.10	49.14	اليمن
Total	6145.95	73671.81	771.33	5953.27	72795.41	742.2	5691.26	71431.71	699.71	5100.44	الجملة

Date palm tree is composed of two major section: *Root_System* 'المجموع الجذري' and *Shoot_System* 'المجموع الخضري'. Each section is divided into sub sections according to Table 3.2 and Figure 3.1.

Table 3.2: Parts of date palm tree[33]

Part	Consists of	Consists of	In arabic
Root_System **القسم الجذري**	Root	Root	الجذر
Shoot_System **القسم الخضري**	Fruit	Date	التمر / البلح
	Flower	Inflorescence	البراعم الزهرية
		Raceme	الشمراخ
		Pollen	الطلع أو الاغريض
		Bunch	العرجون
	Stem	Gemara	الجمارة
		Stem	الساق / الجذع
		Offshoot	الفسيلة
		Developing_Summit	القمة النامية
		Stem_base	قاعدة الساق
	Leaf	Leaf	السعف

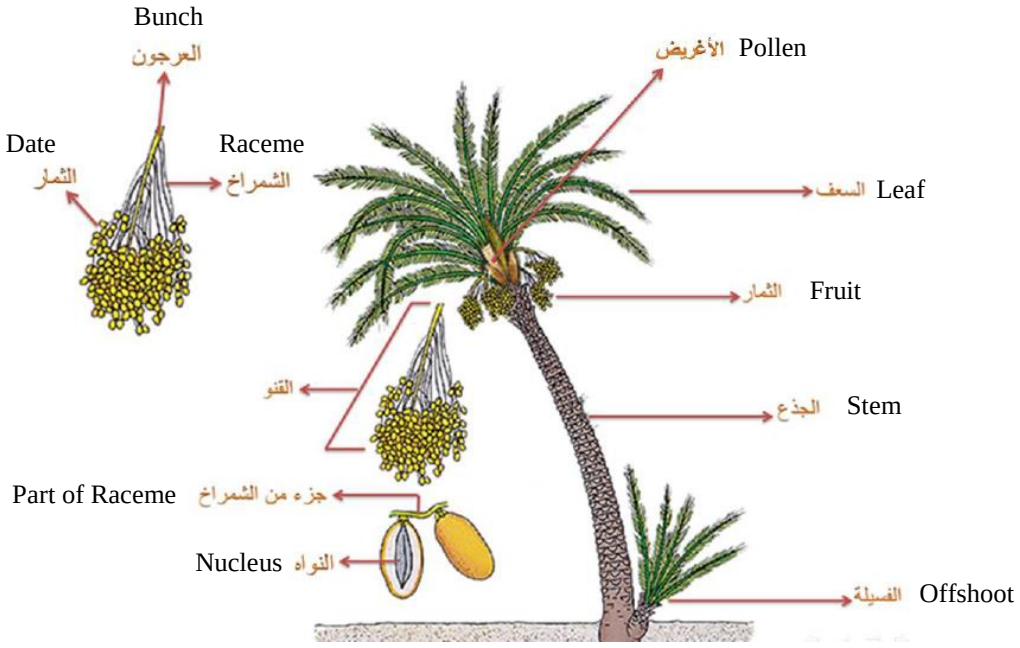

Figure 3.1: Parts of date palm tree [33]

3.2 Plant Protection

This section presents the most important diseases and pests which attack date palm. The information presented includes the distribution, the degree of risk, description and diagnosis of the disease pests and also appropriate treatment.

3.2.1 Plant Disease

A plant disease is any abnormal condition that alters the appearance or function of a plant. It is a physiological process that affects some or all plant functions. Disease may also reduce yield and quality of harvested product. Disease is a process or a change that occurs over time. It does not occur instantly like injury [34]. A disease episode requires the interaction of three components: the host, the pathogen, and the environment.This interaction is known as the disease triangle shown in Figure 3.2.

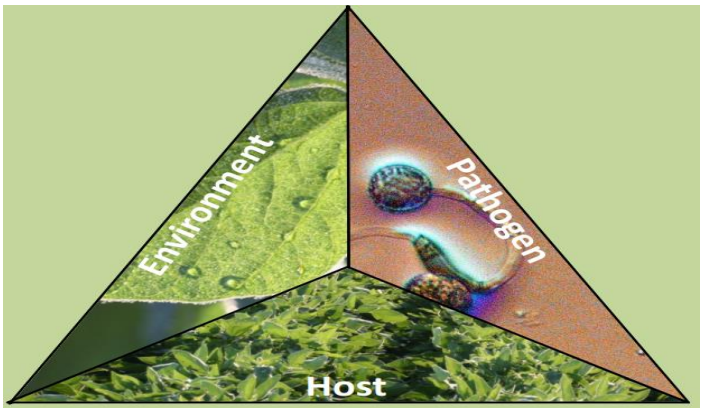

Figure 3.2: The disease triangle [34]

In order for a disease to occur, the host plant must be susceptible to the pathogen (disease organism). First, the plant must be susceptible genetically, meaning that the organism present can cause disease on that plant. In some cases, the host must be at a certain physiological state for disease to occur. Disease only results from the infection

by a virulent pathogen. Most pathogens go through a life cycle in which part of the time the organism is dormant. When a pathogen is dormant, no disease can occur [35].

Although the disease triangle is illustrated by a triangle with all sides equal, the environment really is the most important part of the interaction. The environment must be conducive (favorable) for disease development. That is the temperature, moisture, nutrients, and wind must all favor the pathogen's growth and development.

3.2.2 Pathogens

Many plant diseases are caused by pathogens, which are difficult to see or recognize without magnification. Fungi, bacteria, viruses, nematodes, and even plants can be pathogenic on garden plants (see Figure 3.3). Pathogens generally obtain nutrients, water, and everything they need to reproduce from their host. Such a relationship is called parasitic.

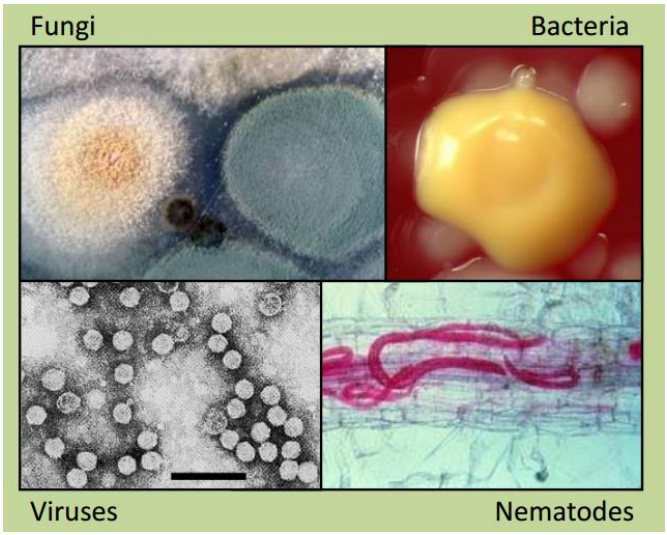

Figure 3.3: Types of pathogens [36]

Fungal and viral pathogens cause many plant diseases; bacterial and nematode pathogens cause a few. Some pathogens can infect several kinds of plants; others require a specific type of host. Pathogens such as fungi and bacteria differ in their ability to survive, spread, and reproduce. Different varieties (strains or races) of a pathogen may differ in how much disease they cause [36].

3.2.3 Symptoms

Symptoms are the visible reactions of a plant to a disease and may suggest a causal agent. A sampling of disease symptoms might include wilting, necrosis, abnormal coloration, defoliation, fruit drop, abnormal cellular growth or stunting of the infected plant. However it is important to remember and frustrating at times to realize that different disease agents can cause similar symptoms on the same host. An equally important point to remember is that insect feeding can also cause "disease like" symptoms on plants [35].

If you can recognize the symptoms, and identify the host plant, you can use various reference materials to make, or at least, narrow down a diagnosis. Signs must be present

on a sample sent for laboratory confirmation of your diagnosis. When examining a plant sample make note of all symptoms and signs.

We divided the symptoms of the three main sections:

1- *Disease_Sign* 'علامة مرضية': Signs are the visible parts of the pathogen or its products seen on the host that can be used to identify the pathogen. Examples of common disease signs would include 'ظهور بثرات على الأوراق'.
2- *Appearance* 'مظهر خارجي': Is what is seen with the naked eye and have a clear. Examples of common disease Appearance would include 'انحناء رأس النخلة'
3- *Color* 'لون ظاهر': note the color change in the part of the plant. Examples of common disease Color would include 'اصفرار السعف الموجود في قلب النخلة'

3.2.4 Environmental Condition

A favorable environment is critically important for disease development even the most susceptible plants exposed to huge amounts of a pathogen will not develop disease unless environmental conditions are favorable. Weather plays a large role in fungal disease development. Most fungi require free water or specific levels of humidity or moisture for prolonged periods of time to develop.

3.2.5 Diagnosing Plant Problems

Plants in our farms will one day have problems. Whether in an effort to save existing plants or prevent problems from recurring, it is important to know "what went wrong." A diagnosis is the process of gathering information about a plant problem and determining the cause and we can define diagnosis is the process of determining the cause of a plant disorder. The process requires a blending of science, experience, observation, and art. Diagnosis is a cooperative effort between the grower and the plant expert. Once the cause has been determined it is then possible to recommend a solution or treatment.

Sometimes you will have insufficient information. Other times, the primary cause of a problem is hidden by other, more obvious, but less important problems. Your success at diagnosing plant problems will be determined by how much you know about the host plant, how much you know about plant problems in general, how good you are at obtaining information from the pathogen.

A diagnosis is made up of seven parts: identifying then plant species, observing, accurate information, sample collection, identifying the cause, confirming the cause and recommendations.

3.2.6 Diseases of Date Palms

Date palm plantations have been suffering from a number of important pests; whether mites, fungi, nematode or insects and more animals. Some of these pests are serious and causes serious damage to date palm plantation. They are consider to be the most serious and important pests, which need a lot of effort and costing a lot of money to control in many Country. These serious pests, also includes; the Red Palm Weevil, which began to spread into many places in the world during the last two decades. The

first record of the red palm weevil in the Gulf Cooperation Council (GCC) Country were in UAE in1985 and Qatar in 1987. Some other pests are less serious and easier to control [16]. Table 3.2 includes the type and number of diseases we are dealing with in our approach. They will be the basis for building our ontology and knowledge base and later used in diagnosis process.

Table 3.3: Table shows the number of diseases used in the system

No.	Disease or Pest	Count
1	Fungi disease	17
2	Undetermined Diseases	6
3	Insects	24
4	Nematodes	3
5	Mite	1
6	Physiological disease	4
7	Animals (Birds – Bat – Rodent)	3
8	Others	1
Total Diseases		59

The following is an example of a pest, its distribution and measures to control it:

Pest name: Dubas Bug 'آفة دوباس النخيل' (*Ommatissus lybicus Bergevin* in Latin)

Distribution: is distributed in Morocco, Algeria, Tunisia, Libya, Egypt, Sudan. In addition, it is widespread in Iraq, Kuwait, Bahrain, Qatar, Saudi Arabia, the United Arab Emirates and the Sultanate of Oman causing serious damage to date palms.

Control Measures: Cultural Control is the cultural control measures depend upon the following points:

- Spacing between date palms: The distance between the date palm should not be less than 8 × 8 meters to allow the wind movements and the sun light between the palms.
- Separating the offshoots from the mother palms: The offshoots should be separated from the mother palms at the right age as their presence around the parent palm increases the relative humidity, which increases the levels of infestation by the Dubas bug and other pests.
- Irrigation: Moderation in irrigation to prevent the increase in relative humidity around the palms, which encourages infestations.

Next, we present a number of the diseases of date palms, their scientific names, English and Arabic names.

1. Fungi diseases in Date Palm الأمراض الفطرية على النخيل

No.	Scientific name	English	Arabic
1	*Alternaria alternate* (Fr.)	Leaf spot diamond	تبقع اوراق (السعف)

2	*Alternaria alternate* *Asp. fumigatus* *Fusarium lateritium*	Date fruit rot	تعفن الثمار
3	*Alternaria* sp.	Punctures palm leaves	تثقب أوراق النخيل
4	*Ceratocystis* sp	Root rot of date palm	عفن جذور نخيل التمر
5	*Colletotrichum gloeosporioides* Sacc.	Anthracnose of date palm	أنثراكنوز النخيل
6	*Diplodia phoenicum*	Diplodia leaf base rot	تعفن قواعد الاوراق الديبلودي
7	*Drechslera australiensis*	Reddish brown parallel spots	بقع بنية صغيرة متوازية
8	*Fusarium oxysporum* f. sp. *Albedinis*	Bayoud	البيوض
9	*Fusarium oxysporum*	Fusarium wilt	الذبول الفيوزارمي
10	*Graphiola phoenicis*	Graphiola leaf spot	تبقع الأوراق الجرافيولي
11	*Mauginiella scaettae*	Inflorescence rot	عفن طلع النخيل (مرض خياس الطلع)
12	*Pestalotiopsis palmarum*	Leaf spot pestalotiopsis	تبقع أوراق بستالتوبيس النخيل
13	*Ganoderma* sp.	Ganoderma	عفن الجونديرما لكرب النخيل
14	*Thielaviopsis paradoxa* Hohn.	Black scorch	اللفحة السوداء (تعفن القمة النامية)
15	*Alternaria alternate*	Brown leaf spot	التبقع البني
16	*Alternaria alternate* (Fr.)	Rectangular pale brown spots	البقع الطويلة القائمة الزاوية
17	*Cladosporium cladosporiodes*	Longitudinal brown spots	البقع البنية المستطيلة

2. Undetermined Diseases أمراض غير معروف مسببها المرضي

No.	English	In arabic
1	Yellowing of the lanner leaves	اصفرار السعف الداخلي
2	Bending head of date palm	انحناء رأس النخيل
3	PuLethal yellowing	الاصفرار القاتل
4	Rapid decline or rhizozis	التدهور السريع
5	Dry bone	العظم الجاف
6	Wajam	الوجام

3. Pest damage of Date Palms آفات خطيرة تصيب نخيل التمر

The pest damage is divided into the following insects, nematode, mites and physiological disease in addition to animal. We present in the tables each of these damage.

3.1 Insects attack Date Palm حشرات تصيب نخيل التمر

No.	Scientific name	English	In arabic
1	*Batrachedra amydraula Meyr.*	Lesser date moth	دودة البلح الصغرى
2	*Arenipses sabella Hampsm*	Greater date moth	دودة البلح الكبرى
3	*Coccotrypes dactyliperda Fab.*	Date seed beetle	خنفساء ثاقبة نوي البلح

4	*Vespa orientalis F.*	Red wasp	دبور البلح الأحمر
5	*Phonapate frontalis sub*	Frond borer	حفار سعف النخيل
6	*Parlatoria blanchardii Targ.*	Parlatoria date scale	الحشرة القشرية المدرعة
7	*Parlatoria blanchardii*	Wheat date scale	الحشرة القشرية البيضاء
8	*Asterolecanium Phoenisic*	The green soft scale	الحشرة القشرية الخضراء
9	*Phoenicoccus marlatti (CKLL)*	Red date scale	الحشرة القشرية الحمراء
10	*Maconellicoccus hirsutus Green*	Mealy Bugs	بق النخيل الدقيقي
11	*Ommatssus binotatus Fiber*	Date palm dubas bug	دوباس النخيل
12	*Schistocerca gergaria Forskal*	Desert Locusts	الجراد الصحراوي
13	*Microcerotermes diversus*	Termites	النمل الابيض
14	*Gryllotalpa gryllotalpa L*	The mole cricket	الحفار / كلب البحر
15	*Pseudophilus testaceus Gah.*	The longhorn date palm stem borer	حفار ساق النخيل ذو القرون الطويلة
16	*Oryctes elegans Prell*	Fruit stalk borer	حفار عذوق النخيل
17	*Rhynchophorus ferrugineus Oli.*	Red palm weevil	سوسة النخيل الحمراء
18	*Xyleborus perforans Woll.*	Bark beetle	خنفساء القلف
19	*Carpophilus dimidiatus (Fab)*	Dried fruit beetle	خنفساء الثمار الجافة
20	*Oryzaephilus surinamensis L.*	Saw-Toothed grain beetle	خنفساء ذات الصدر المنشاري
21	*Oryctes rhinoceros*	Rhinoceres beetle	خنفساء رينوسيرس
22	*Cadra cautella*	Almond moth	دودة البلح العامري
23	*Deudorix (Virachola) livia Klung*	Pomegranate fruit butterfly	دودة ثمار الرمان
24	*Plodia interpunctella Hubn.*	Indian meal moth	فراشة الدقيق الهندية

3.2 Nematodes Attack Date Palm نيماتودا تصيب نخيل التمر

No.	Scientific name	English	In arabic
1	*Tylenchorhynchus* Spp.	Stunt nematodes	نيماتودا التقزم
2	*Meloidogyne* spp.	Root-Knot nematodes	نيماتودا تعقد الجذور
3	*Pratylenchus* Spp.	Lesion nematodes	نيماتودا تقرح الجذور

3.3 Mites Attack Date Palm عث يصيب نخيل التمر

No.	Scientific name	English	In arabic
1	*Oilgonychus afrassiaticus*	Old world date mite	حلم الغبار

3.4 Physiological Diseases أمراض فسيولوجية

No.	English	In arabic
1	Yellowing leaves of modern central crown Palm	اصفرار الأوراق الحديثة بوسط تاج النخلة
2	Potassium deficiency	الاصفرار الناتج عن نقص البوتاسيوم
3	Magnesium deficiency	الاصفرار الناتج عن نقص الماغنيسيوم
4	Nitrogen deficiency	الاصفرار الناتج عن نقص النيتروجين

3.5 Animal Damage of Date Palms and Others خطر حيوانات على نخيل التمر وأخرى

No.	English	In Arabic
1	Bats	الخفافيش
2	Rodent – Black rat	القوارض – الجرذ الأسود
3	Rodent – House mice	القوارض – الفأر المنزلي
4	Birds	الطيور
5	Cochicella acuta	القواقع – قواقع النخيل

3.3 Semantic Web and Ontology

In this section we present the definition of ontology, how it is developed, the tools and software used to build it. Since ontology belongs to the area of semantic web, we introduce the semantic web and the position of ontology a central part of it.

3.3.1 Semantic Web

The Semantic Web is an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation" [37]. The goal of the semantic web is to make the web more understandable and accessible by machines.

The development of the web was one of the greatest inventions of recent times. Berners-Lee proposed the systematic structure of Semantic Web, which includes of seven layers: UNICODE and URI, XML, RDF, Ontology, Logic, Proof, Trust as shown in Figure 3.4.

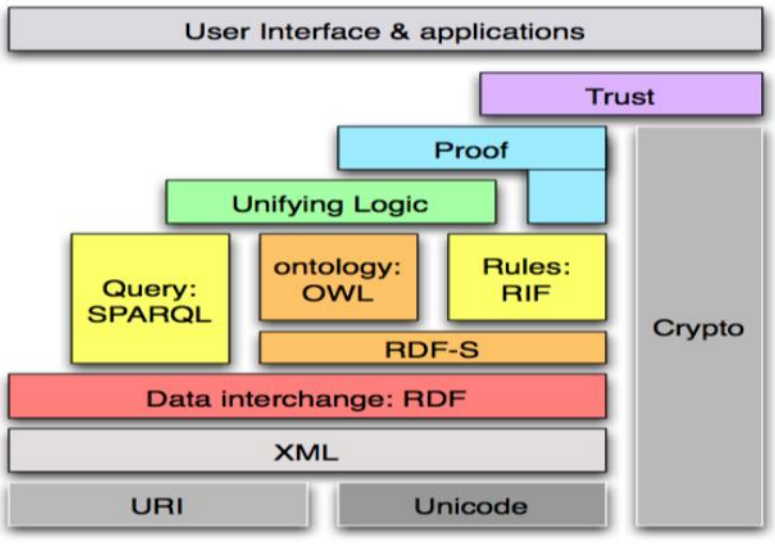

Figure 3.4: Layered approach of the semantic web [38]

In these layers, the hardcore layers are XML, RDF, and ontology they are used to describe semantics of web information. At the bottom is URL which is used to represent the resources while the XML is a kind of language to describe resources. It fits to express all kinds of information and been regarded as a standard for data exchange. RDF recommended as a protocol to describe and deal with metadata by W3C, It provide

some information understood by computer for applications alternation on the web. XML and RDF can all provide semantic for computer resources [38]. By using XML, RDF information can easily be exchanged between different types of computers using different types of operating systems and application languages. Information is represented by triples *subject-predicate-object* in RDF. [39]

3.3.2 Ontology

Ontology is defined as "*a formal explicit description of concepts in a domain of discourse (classes). Properties of each concept describe various features and attributes of the concept (slots), and restrictions on slots (facets) ontologies together with a set of individual instances of classes constitutes a knowledge base*" [29].

Ontology is an explicit specification of a set of objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold them. Ontology is a formal specification of a shared conceptualization [40]. Ontology is a formal explicit representation of concepts in a domain, properties of each concept describes characteristics and attributes of the concept known as slots and constrains on these slots. Ontology is a shared conceptualization with a clear hierarchy and a strong support for logical consequences [41]. Class is the core of ontology, which describes the concepts in some domain. Slot describes the property of the class and the instance.

Ontologies play an increasingly important role in knowledge management and is used as a standard knowledge representation for the Semantic Web. By ontology the users can connect with each other using a common understanding of a domain. This helps in understanding the concepts of the domain as well as helps the machine to interpret the definitions of concepts in the domains and also the relations between them [42].

There are many benefits of ontology which could be summarized as follows [19]:

- Ontology offers a method to encode knowledge to allow the machines to understand what they present .
- Ontology offers a common vocabulary for a specific domain.
- Ontology is used to define a vocabulary to structure the RDF documents we create.
- Ontology promotes and encourages reuse of domain knowledge.
- Everything we say about a given resource, we have a reason to say it.
- To share a common understanding of the structure of information among people or software agents
- To separate and analyze domain knowledge from the operational knowledge

3.3.2.1 Ontology Building Methodologies

Ontology building is not a simple task; it needs time, effort and expertise in the domain in which we want to build the ontology. A team of people, such as domain experts and ontological engineers, normally carries out the development of ontology.

Noy and McGuinness [14] enumerate the stages involved in developing ontology. They include the following steps:

1- Determine the domain and scope of the ontology
2- Consider reusing existing ontologies
3- Enumerate important terms in the ontology
4- Define the classes and the class hierarchy
5- Define the properties of classes-slots
6- Define the facets of the slots
7- Create instances

We explain briefly each of these steps and in Chapter 4, we employ them to build our ontology (*AgriDPalmOnto*).

Step 1. Determine the domain and scope of the ontology

This step defines the domain and the purpose of the ontology. Developing an ontology is not an aim or a goal in itself but we build the ontology for a particular purpose. That is, answer several basic questions: what domain will the ontology cover? What is the purpose of the ontology? For what sorts of questions should the information in the ontology be able to provide answers? [43].

Step 2: Consider Reusing Existing Ontologies

This step is to ascertain if ontology has developed previously in the same subject area. If such ontology exists, it is easier to modify the existing ontology to suit ones needs than to create a new ontology [46]. Reusing existing ontology may be required if our system needs to interact with other applications that have been committed to a specific ontology or controlled vocabulary.

Step 3. Enumerate important terms in the ontology

This is step is consider as the first step or the actual definition of the ontology where we make a list of an expected terms that will be used on the ontology building. It is important to get a comprehensive list of these terms without fear of overlap between concepts they represent or relations among the terms.

Step 4: Define the Classes and the Class Hierarchy

There are several possible approaches in developing a class hierarchy [19]: a top-down development process, which starts with the most general concepts and subsequent specialization of the concepts. Bottom-up starts with the most specific concepts or classes, the leaves of the hierarchy with subsequent grouping of these classes into more general concepts. Then we specialize the class by creating some of its subclasses and so on. A bottom-up development process starts with the definition of the most specific classes then leaves of the hierarchy with subsequent grouping of these classes into more

general concepts. A combination development process of the top-down and bottom up approaches is also possible.

Step 5. Define the properties of class-slots

In this step, the classes that are created in the previous step does not provide enough information alone. So once we have selected the defined classes in the list of terms we created in Step 3, most of the remaining terms consider properties (slots) of these classes [46]. Where for each property in the list, we have to show which class it describes.

Step 6: Define the Facets of the Slots.

This step involves attaching facets to the properties, i.e., describing the value type, allowed values, the number of allowed values (cardinality) and other features that are necessary. In this way, constraints placed on the types of data that allowed.

Step 7: Create Instances

The last step allows the data to entered and displayed. An instance (or individual) is the information that entered into the knowledge base. To create an instance the following method needs to carried out:

1- Choosing a class.
2- Creating an instance and name instance after the source.
3- Filling the slot values.

3.3.2.2 Ontology Evaluation

The evaluation of the quality of ontology is an important part of ontology development. We present the evaluation methodology we use to evaluate the *AgriDPalmOnto*.

An ontology can be evaluated against many criteria: its coverage of a particular domain and the richness, complexity and granularity of that coverage; the specific use cases, scenarios, requirements, applications, data sources it was developed to address, formal properties such as the consistency and completeness of the ontology and the representation language in which it is modeled [44]. Most evaluation approaches fall into one of the following broad categories [45].

1- Comparing the ontology to a golden standard, may be the ontology itself.
2- Using the ontology in an application and evaluating the results
3- Comparing with a source of data (e.g. a collection of documents) about the domain to be covered by the ontology.
4- Evaluation is done by humans who try to assess how well the ontology meets a set of predefined criteria, standards and requirements.

Table 3.4 show an overview of approaches to ontology evaluation that following golden standard, application based, data driven and assessment by human.

Table 3.4: An overview of approaches to ontology evaluation [45]

Level	Golden standard	Application -based	Data-driven	Assessment by humans
Lexical, vocabulary, concept, data	×	×	×	×
Hierarchy, taxonomy	×	×	×	×
Other semantic relations	×	×	×	×
Context, application		×		×
Syntactic	×			×
Structure, architecture, design				×

- **The Golden standard evaluation**: the golden standard could be in fact another ontology, or it could be taken statistically from a corpus of documents or prepared by domain experts. In Table 3.4 The lexical content of an ontology can also be evaluated using the concepts of precision and recall, in this case, the precision would be the percentage of the ontology lexical entries that also appear in the golden standard, relative to the total number of ontology words. Recall is the percentage of the golden standard lexical entries that also appear as concept identifiers in the ontology, relative to the total number of golden standard lexical entries. The same approach used to evaluate the lexical content of an ontology on other levels, e.g. instances, relations [45].
- **Application based evaluation**: where the ontology will be used in some kind of application or task. The outputs of the application, or its performance on the given task, might be better or worse depending on the ontology used in it. So one might say that a good ontology is one which helps the application in question produce good results on the given task. Ontologies may therefore be evaluated simply by plugging them into an application and evaluating the results of the application [45].
- **Data-driven evaluation**: An ontology may also be evaluated by comparing it to existing data (usually a collection of textual documents) about the problem domain to which the ontology refers [45].
- **Assessment by humans evaluation**: this evaluation is done by humans who try to assess how well the ontology meets a set of predefined criteria, standards, requirements [45].

Task-based evaluations show a useful framework for measuring practical aspects of ontology deployment, such as :

- The human ability to formulate queries using the query language provided by the ontology.
- The accuracy of responses provided by the system's inferential component.
- The degree of explanation capability offered by the system.
- The coverage of the ontology in terms of the degree of reuse across domains.
- The scalability of the knowledge base.
- The ease of use of the query component.

Task-Based evaluations can leverage use-cases or scenarios to characterize the target knowledge requirements [46]. In a Task-Based evaluation, the results should show the following shortcomings:

- Insertion errors indicating superfluous concepts,
- Deletion errors indicating missing concepts, and
- Substitution errors indicate off-target or ambiguous concepts.

With this, we can provide performance measures that can:

- Evaluate one or more ontologies in terms of their performance on a given task (ideally to measure only the ontology-specific aspect of the performance),
- Quantify the respective gains and losses of the insertion, deletion and substitution errors,
- Populate/improve the ontology as derived from the individual error type specific results, and
- Re-evaluate the respective performance increases resulting from the improvements.

By applying this evaluation scheme, we can test and measure the respective improvements that brought about by learning approaches that target the same levels and issues in the ontology learning and population field [47].

3.3.2.3 Ontology Tools

- **Web Ontology Language (OWL)**

OWL is a well-known standard of ontology language recommended by W3C [48]. OWL describes the structure of a domain in terms of classes, properties, individual and restrictions. Its constructors of classes and properties have rigorous formal foundation based on Description Logic and there exists decidable reasoning algorithms when OWL is used under some restrictions. Individuals represent objects in the domain, maybe members of one or more classes. Properties describe the relationships between individuals, link two individuals. Classes, also known as sets members of classes, share some properties or characteristics.

OWL has three increasingly-expressive sublanguages [49]: OWL-Lite, OWL-DL, and OWL-Full designed for use by specific communities of implemented and users. OWL-Lite is the least expressive sub-language it intended to use in situations where only a simple class hierarchy and simple constraints needed. For example, while it supports cardinality constraints, it only permits cardinality values of 0 or 1. It should be simpler to provide tool support for OWL-Lite than its more expressive relatives, and OWL-Lite provides a quick migration path for thesauri and other taxonomies. OWL-Lite also has a lower formal complexity than OWL-DL. OWL-DL considered as an extension of OWL-Lite and OWL-Full an extension of OWL-DL. OWL-DL includes all OWL language constructs, but they can be used only under certain restrictions (for example, while a class may be a subclass of many classes, a class cannot be an instance

of another class). OWL-Full is the most expressive sub-language it intended to use in situations where very high expressiveness is more important than being able to guarantee the decidability or computational completeness of the language. It is therefore not possible to perform automated reasoning on OWL-Full ontologies.

There are two important types of properties in OWL [50]: data type properties and object properties. Data type properties help describe individuals, they are not typically used to describe classes and are certainly not dependent on classes. Object properties allow you to create associations or relationships between two individuals. That means the subject and the object the triple are both individuals.

- **Protégé**

Protégé [18] is an integrated software tool used by system developers and domain experts to develop knowledge-based systems. Protégé can be characterized as an ontology development environment. It provides functionality for editing classes, properties, and individuals. At its core, Protégé implements a rich set of knowledge-modeling structures and actions that support the creation, visualization, and manipulation of ontologies in various representation formats. Protégé can customize to provide domain-friendly support for creating knowledge models and entering data. Further, Protégé can extend by way of a plug-in architecture and a Java based Application Programming Interface (API) for building knowledge-based tools and applications.

The Protégé-OWL API is an open-source Java library for the Web Ontology Language and RDF(S). The API provides classes and methods to load and save OWL files, to query and manipulate OWL data models, and to perform reasoning. Furthermore, the API optimized for the implementation of graphical user interfaces [51].

- **Protocol and RDF Query Language (SPARQL)**

SPARQL is the standardized query language for RDF, the same way SQL is the standardized query language for relational databases. There are some similarities because it shares several keywords such as SELECT, WHERE, etc. It also has new keywords that you have never seen in a SQL world such as OPTIONAL, FILTER and much more [52]. SPARQL is powerful, flexible, and allows the use of RDF, with all of its advantages over traditional databases. However, SPARQL query construction has been described as “absurdly difficult”, and even experienced users may struggle with it. For this reason, various methods have been suggested for aiding in SPARQL query generation, including assisted query construction [53].

- **DL Query**

The DL Query provides a powerful and easy-to-use feature for searching a classified ontology. The query language (class expression) based on the Manchester

OWL syntax, a user-friendly syntax for OWL DL that fundamentally based on collecting all information about a particular class, property, or individual into a single construct, called a frame [54].

- **JENA**

JENA is A free and open source Java framework for building Semantic Web and Linked Data applications, we will use Jena Ontology API that work with models, RDFS and the Web Ontology Language (OWL) to add extra semantics to your RDF data [55].

- **Reasoner**

Reasoner is a key component for working with OWL ontologies. Virtually all querying of an OWL ontology should be done using a reasoner. This is because knowledge in an ontology might not be explicit and a reasoner is required to deduce implicit knowledge so that the correct query results are obtained. There following reasoners provide implementations of the OWL API OWLReasoner interface: FaCT++, JFact, HermiT and Pellet. We like Pellet is an OWL2 reasoner. Pellet provides standard and cutting-edge reasoning services for OWL ontologies [56].

OWLViz plugin used in protégé software that enables class hierarchies in an OWL ontology to be viewed and incrementally navigated and allowing comparison of the asserted class hierarchy and the inferred class hierarchy [57].

3.4 Summary

In this chapter, we have presented a background for this research. We presented date palm and its parts and show the concept of plant protection including the concept of disease, diagnosis, pathogen, symptoms, environment condition and others. Additionally, we defined the semantic web and ontology and explained the steps that must be followed to build it. We also identified the terminology of OWL, SPARQL and DL query and tools to be used in the construction and programming in our approach such as Protégé, JENA and OWLViz plugin.

Chapter 4
AgriDPalmOnto Development

In this chapter, we present the steps to develop the date palm domain ontology (*AgriDPalmOnto)* to be used as a basis to diagnose the diseases of date palm and speed up the acquisition of related knowledge. We present concrete steps on developing the ontology and realizing it in a specific development environment namely, protégé. We also present the evaluation of the *AgriDPalmOnto*.

4.1 AgriDPalmOnto Development

The proposed *AgriDPalmOnto* system is very important for diagnosing date palm diseases. Due to the lack of diagnosing date palm diseases in agriculture field in Arab World, we are going to design a new ontology to be used for diagnosing date palm diseases. There exists no such ontology.

The ontology content is related to agriculture domain and is collected from a number of relevant research papers and documentations related to date palm diseases and diagnosis of such diseases. The *AgriDPalmOnto* ontology is developed with the assistance of a domain expert. He helped to identify concepts, relationships, and definitions of the disease of date palm domain. The advantage of the ontology model is easy extensibility, the possibility to query and manage additional information that might be related to the diagnosis result.

There are many different tools available for developing ontologies such as Hozo, DOML, and AltovaSemantic Works etc. We use Protégé which is one of the most widely used ontology development editor that defines ontology concepts (classes), properties, taxonomies, various restrictions and class instances. It also supports several ontology representation languages, including OWL[58]. Building the ontology consists of the following steps:

Step 1: Determining the Domain and Scope of the Ontology
Step 2: Reuse Existing Ontologies
Step 3: Overview of Ontology
Step 4: Enumerate the Important Terms in AgriDPalmOnto
Step 5: Define Classes and Class Hierarchy of AgriDPalmOnto
Step 6: Define the Properties of Classes (Slots)
Step 7: Define the Facets of the Slots
Step 8: Create instances of AgriDPalmOnto.
Step 9: Apply Ontology Reasoner

Step 1: Determining the Domain and Scope of the Ontology

Developing ontology without any purpose is not a goal in itself. Ontology is a model of a particular domain built for a particular purpose. Ontology is by necessity an abstraction of the construction of a domain determined by the use to which the ontology

will put and by future extensions that are already anticipated. Defining ontology domain and scope requires answering some basic questions:

1. ***What is the domain that the ontology will cover?***
   The domain of the ontology is diagnosing date palm diseases.
2. ***What is the use of the ontology?***
   The ontology is to provide a knowledge base of diseases, pests, pathogens and symptoms. It will be used in a system to make diagnoses of the diseases of date palm and determine the cases of these diseases.
3. ***What types of questions would be answered by the information contained in the ontology?***
   The ontology would provide comprehensive answers to questions related to date palm disease domain such as:
   - What are the common diseases in a particular Country?
   - What are the Country where there is a specific disease?
   - What is a pathogen for a particular disease?
   - What are the symptoms of a particular disease?
   - What is the diagnosis of disease specific symptoms?
   - What is the appropriate treatment for a particular disease?
   - What are the symptoms that affect a particular part of the palm tree?
   - What is the part of the tree infected certain symptom?
4. ***Who will use the ontology?***
   The ontology will be available to the *AgriDPalmOnto* system to be developed in this research to diagnose the diseases of date palm. Users include date palm farmers, experts and specialist in the agriculture filed. Ordinary users who are interested in growing and caring of date palm.
5. ***Why to develop such ontology?***
   By developing ontology we can share the common understanding of the structure of information among users or software agents. Different websites may contain variety of details about diagnosing the diseases of date palm. Ontology where fundamental in our system, where contain enough information about the diseases, symptoms etc. Information retrieval is done through the language queries will be explained later. Through ontology all these information can be aggregated and can be published. The users and agents can use this aggregated information to answer user queries or as input data to other applications. The developed ontology can be reused in the future for other purposes. To build a larger ontology, the existing ontologies describing portions of the large domain can be integrated. We can conclude that of *AgriDPalmOnto* is to speed of response and accuracy in information and extract new information resulting from relations in it.

Step 2: Reuse Existing Ontologies

With the enormous application of semantic web, ontologies are becoming more widely available. There is no single standard way to develop ontology. It is not

necessary to start from scratch always. We use PPOntology[59] as a basis for developing the *AgriDPalmOnto*. This work is still in its infancy, where the author develop a vision for a preliminary Anthology Plant Protection barley and contained many errors. We have to take advantage of some of the classes and relations and used it to determine the method of building ontology, as well as to identify some relationships and properties in the diagnosis of diseases. We benefited from this ontology to identify some of the properties.

Step 3: Overview of Ontology

We identify some diseases, pest, diagnosis, symptoms, treatments and data that are needed in the process of diagnosing date palm diseases in our approach [Appendix A]. Our ontology is represented in OWL. it can be reused by other applications interested in the same domain. We name our ontology *AgriDPalmOnto* as a short name for Agriculture Diseases Palm Ontology. Figure 4.1 illustrates the core classes of the *AgriDPalmOnto* as well as the relationships among them. It has 479 classes, 15 object properties, and 6 data properties (more details show Appendix A).

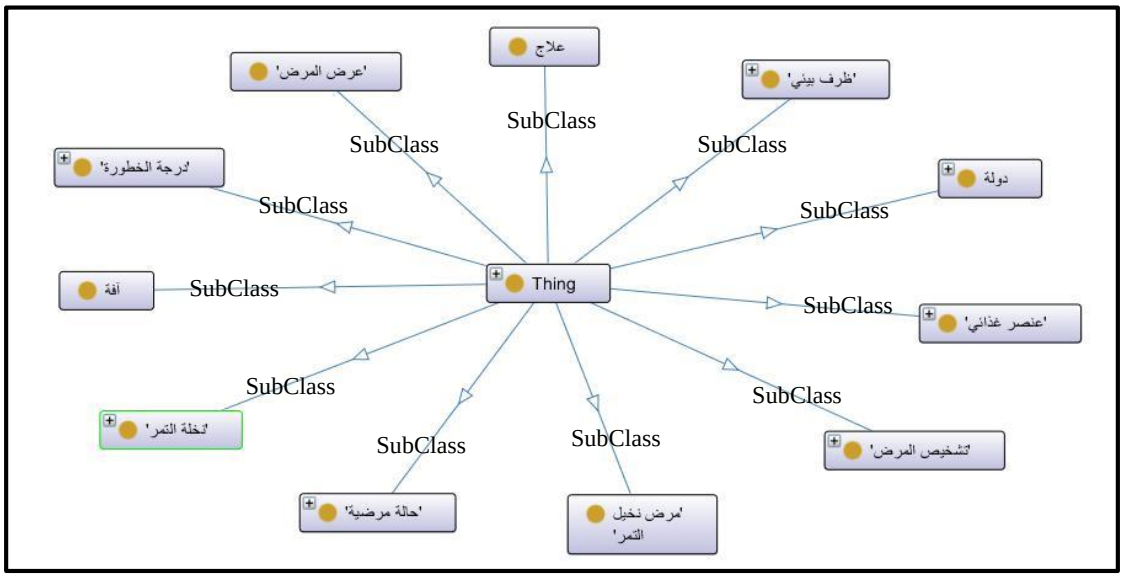

Figure 4.1: Main classes in AgriDPalmOnto

Step 4: Enumerate the Important Terms in the AgriDPalmOnto

This step represents a brainstorming activity. We add terms and properties for these terms by studying the science of disease diagnosis which is explained in Section 3.2, and through analyzing the structure of disease, pathogen and symptoms. The following questions guide our brain storming activity to determine the terms:

1. ***What are the main terms that we want to talk about?***

   The main terms we talk about are *Pest*, *Country*, *DPalm*, *Diagnosis_of_disease*, *Case_of_disease*, *Treatment*, *Nutrient*, *Environmental_condition*, *Disease_dp*, *Degree_of_danger* and *Symptom_dp*. Table 4.1 shows these terms, describes each one with its name in English and Arabic, its importance and why we need it in our approach. Choosing these terms

has direct relation with user requirements used in the process of diagnosis and search.

Table 4.1: Main terms in AgriDPalmOnto

No	Term	Full name in English	In Arabic	Importance
1	***Country***	Arab country is famous for its date palm	دولة عربية تشتهر بنخيل التمر	We need this, to see the most common diseases in each country and ease of classification and naming. That contains 15 Arab Country.
2	***DPalm***	Date palm tree	شجرة نخيل التمر	We need this, to classify symptoms as the infected palm part. Palm has been divided into two parts, root and shoot system.
3	***Pest***	Disease causing microorganisms, such as bacteria, fungi, and viruses etc.	آفة من كائنات دقيقة مثل الفيروسات والبكتيريا والفطريات وغيرها	We need this, because the pest is a main player in the disease.
4	***Diagnosis_of_disease***	Diagnosis of disease in date palm	تشخيص مرضي في نخيل التمر	We need this, because of identifying the symptoms of each disease separately.
5	***Case_of_disease***	Cases of disease in date palm	حالة مرضية ضمن ظروف معينة لنخيل التمر	We need this, because of determining ripe conditions for each case disease.
6	***Treatment***	Method of treatment	طريقة علاجية للأمراض	We need this, because of determining appropriate treatment for each disease or pest
7	***Nutrient***	The nutritional components in soil	عنصر غذائي في التربة	We need this, owing to identify other causes of disease.
8	***Environmental_condition***	Environmental condition such as humidity.	الظرف الجوي والبيئي من حرارة ورطوبة	We need this, because of determining the appropriate environmental conditions for disease activity
9	***Symptom_dp***	Classification symptoms of date palm	عرض المرض والمشاكل في شجرة النخيل	We need this, because classification of symptoms gives ease in the diagnosis and distinguish between them.
10	***Degree_of_danger***	The degree of danger for the disease	درجة خطورة المرض	We need this, because classification of danger to levels.
11	***Disease_dp***	Disease of date palm	مرض نخيل التمر	We need this, because the disease is very important.

2. What are the properties of these terms? What is needed to be said about those terms?

- The *Country* term has the following properties: *spread_out*, *name* and *image*.
- The *DPalm* term has the following properties: *has_part* and *name*.

- The *Pest* term has the following properties: *factor_of, has_case, has_treatment, widespread_in, name, common_name, Scientific_name and image.*
- The *Disease_dp* term has the following properties: and *has_factor, Scientific_name, name, image.*
- The *Diagnosis_of_disease* term has one properties: *has_symptom.*
- The *Case_of_disease* term has the following properties: *case_of, has_condition, has_dangerous* and *has_diagnosis*.
- The *Treatment* term has the following properties: *treatment_of, name, description* and *concentration.*
- The *Nutrient* term has the following properties: *factor_of* and *name*.
- The *Environmental_condition* term has one properties: *description*.
- The *Symptom_dp* term has the following properties: *location_in, description* and *image.*

Step 5: Define Classes and Class Hierarchy of AgriDPalmOnto

This step starts by defining classes. From the list, which is created in Step 3, terms are selected whether they describe objects having independent existence or terms that describes these objects. The terms in Table 4.2 are sub classes in the ontology and will become anchors in the class hierarchy. Classes also are organized into a hierarchical taxonomy.

Table 4.2: AgriDPalmOnto sub classes

No.	Class in English	In Arabic	Description
1	*Root*	جذر	Represents the bottom planted in the ground
2	*Fruit*	ثمرة	Represents the fruit of dates
3	*Flower*	زهرة	Represent flowers stage before maturity
4	*Stem*	ساق	Represent the main axis of a palm tree
5	*Leaf*	سعف	Leaf represent wicker, thorns and base leaf
6	*Inflorescence_Flower*	برعم زهري	Represents the inflorescence of flower
7	*Raceme_Flower*	شمراخ	Represents the raceme of flower
8	*Bunch_Flower*	عرجون	Represents the bunch of flower
9	*Pollen_Flower*	طلع	Represents the pollen of flower
10	*Humidity*	رطوبة	Represent case of air humidity
11	*Temperature*	درجة الحرارة	Represent air temperature
12	*Micro_nutrient*	عنصر غذائي صغير	Represents the nutrients needed by plants in small quantities
13	*Macro_nutrient*	عنصر غذائي كبير	Represents the nutrients needed by plants in large quantities
14	*Pest*	آفة	Every living organism causing economic harm to plants
15	*Animal_Pest*	آفة حيوانية	Are living organisms causes on the plant
16	*Nematode_Pest*	آفة نيماتودا	Are living organisms causes on the plant
17	*Insect_Pest*	آفة حشرية	Are living organisms causes on the plant
18	*Mite_Pest*	آفة آكاروسية	Are living organisms causes on the plant
19	*Microorganism*	آفة بكتيرية	Represents different kind of the pest Microorganism
20	*Bacterium_Pest*	آفة جرثومية	Are living organisms causes on the plant
21	*Fungue_Pest*	آفة فطرية	Are living organisms causes on the plant
22	*Bat_Pest*	آفة خفاش	Are living organisms causes on the plant
23	*Bird_Pest*	آفة طير	Are living organisms causes on the plant

24	*Rodent_Pest*	آفة قارض	Are living organisms causes on the plant
25	*Snail_Pest*	آفة قوقع	Represents kinds of harmful snails
26	*Degree_of_danger*	درجة الخطورة	Represent the degree of risk of the disease on the plant
27	*Vital_Treatment*	علاج حيوي	Is use of traditional means unusual for treatment
28	*Chemical_Treatment*	علاج كيميائي	Is use of a particular pesticide chemical concentration for treatment
29	*Undetermined_disease*	مرض غير معروف	Represents many diseases is unknown Pathogen
30	*Plant_fungal*	مرض فطري	Represents many diseases of fungal type
31	*Virus_Disease*	مرض فيروسي	Represents many diseases of virus type
32	*Germ_Disease*	مرض جرثومي	Represents many diseases of germ type
33	*Disease*	مرض نباتي	Represent things other than diseases
34	*Physiological_disease*	مرض فسيولوجي	Represents kinds of physiological diseases such as Magnesium deficiency
35	*Diseases_sign*	علامة مرضية	Represents the symptoms of the disease by Diseases Signs
36	*Color*	لون ظاهر	Represents the symptoms of the disease by Color
37	*Appearance*	مظهر خارجي	Represents the symptoms of the disease by Appearance

After the identification of key terms, these terms must be organized in a taxonomic hierarchy. There are three possible ways to develop the class hierarchy [19]: top-down approach, bottom-up approach, or combination of both. It is important to ensure that the hierarchy is a taxonomic hierarchy. That is if B is a subclass of A, then every instance of B must also be an instance of A. Only this will ensure that we follow the built in semantics of primitives such as *owl:subclassOf* and *rdfs:subClassOf*. In our approach, we use the top level concept such as *Country*, *DPalm*, and *Disease_dp*. Then we generate all other classes that could expand from *DPalm* and *Disease_dp*.

Step 6: Define the Properties of Classes (Slots)

Properties define the relationships between two objects. There are two types of properties. Object properties and data properties. Object properties are used to link object to objects. Data Properties are used to link objects to xml schema data type. Once we defined the classes, we clarify and reflect the internal structure of concepts. This is considered as the property of the developed classes. These properties are extracted from classes that are illustrated in Table 4.3 For Example: *Pest* has two types of *Pest*, which are *Animal_Pest* and Plant_Pest. *Animal_Pest* has eight types of *Pest*, which are *Nematode_Pest, Mite_Pest, Microorganism_Pest, Insect_Pest, Bat_Pest, Bird_Pest, Rodent_Pest* and *Snail_Pest*. Every instance of *Snails_Pest* has properties such as *has_case, widespread_in, factor_of* and *has_treatment*. Figure 4.2 shows the relation of proprieties between main classes.

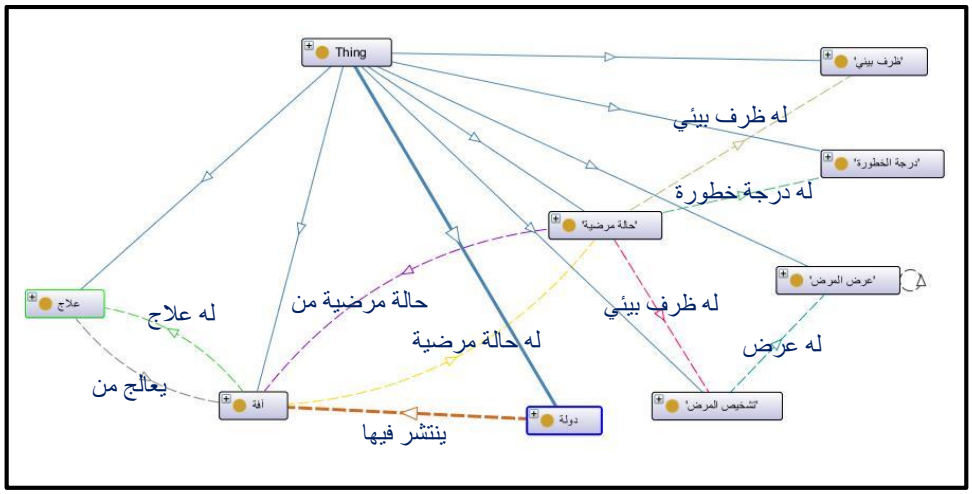

Figure 4.2: The properties of AgriDPalmOnto

Figure 4.2 shows the properties of Bayoud disease.

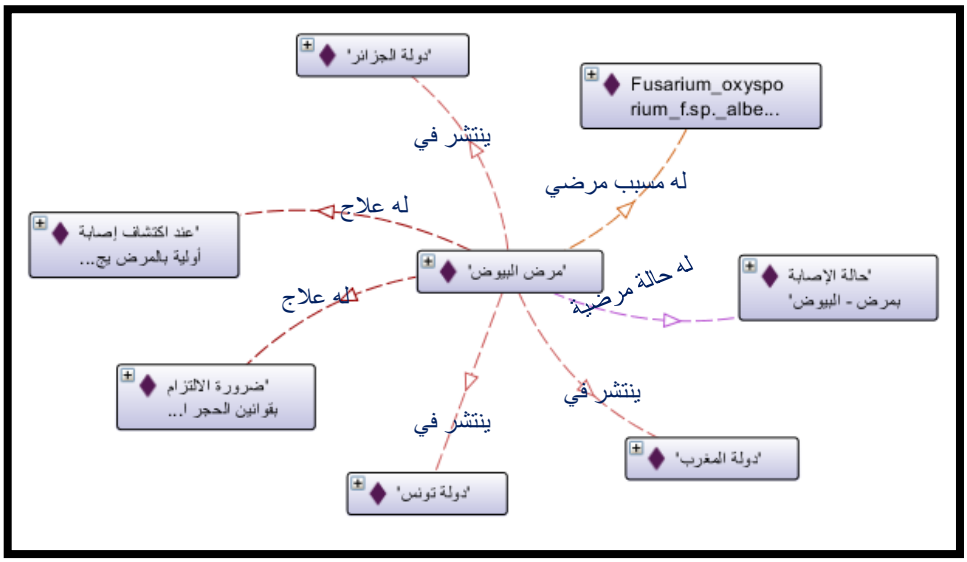

Figure 4.3: The properties of Bayoud disease

Table 4.3 shows the basis of main object properties that uses in AgriDPalmOnto and determine the domain and range for them.

Table 4.3: AgriDPalmOnto object properties

No.	Object Properties	In Arabic	Domain	Range	Characteristic
1	part_of	جزء من	1-9 in Tabel 4.2	DPalm	-
2	has_part	له جزء	DPalm	1- 9 in Table 4.2	-
3	*case_of*	حالة مرضية لـ	*Case_of_disease*	*Pest, Disease_dp*	*Functional*
4	*has_case*	له حالة مرضية	*Pest, Disease_dp*	*Case_of_disease*	*Inverse Functional*
5	*has_diagnosis*	له تشخيص مرضي	*Case_of_disease*	*Diagnosis_of_disease*	-
6	*has_factor*	له مسبب مرضي	*Plant_Disease, Physiological_disease*	*Pest or Nutrient*	-

7	*factor_of*	مسبب مرضي لـ	*Pest or Nutrient*	*Plant_Disease, Physiological_disease*	-
8	*has_condition*	له ظرف بيئي	*Case_of_disease*	*Environmental_condition*	-
9	*has_symptom*	له عرض	*DPalm*	*Symptom_dp*	*Inverse Functional*
10	*observed_problem*	يلاحظ أعراض لـ	*Diagnosis_of_disease*	*Symptom_dp*	-
11	*similar_sympt om*	له نفس العرض	*Symptom_dp*	*Symptom_dp*	*Symmetric And transitive*
12	*has_dangerou s*	له خطورة	*Case_of_disease*	*Degree_of_danger*	*Functional*
13	*widespread_in*	ينتشر في	*Pest*	*Country*	-
14	*location_in*	موقعه في	*Symptom_dp*	*DPalm*	*Functional*
15	*treatment_of*	يعالج من	*Treatment*	*Pest*	-
16	*has_treatment*	له علاج	*Pest*	*Treatment*	-
17	*spread_out*	ينتشر فيها	*Country*	*Pest*	

Data properties such as *name*, *common_name* and *image* etc. is added to the ontology. They are used to link an instance and a class. For giving a value to an instance in a class, we use data properties. For example the common name for "*The_red_palm_weevil*",'سوسة النخيل الحمراء' is "Indian palm weevil",'سوسة النخيل الهندية' or "Asian palm weevil",'سوسة النخيل الآسيوية'. The data property is applicable to each instance of a class. It can't be applied to a general class. Table 4.4 illustrates the data properties of AgriDPalmOnto ontology.

Table 4.4: AgriDPalmOnto data properties

No.	Data properties	In Arabic	Domain	Range
1	*name*	اسم	*Country* or *Disease_dp* or *Pest*	Literal
2	*common_name*	اسم شائع	*Country* or *Disease_dp* or *Pest*	Literal
3	*scientific_name*	اسم علمي	*Pest, Disease_dp*	Literal
4	*concentration*	تركيز	*Chemical*	Literal
5	*description*	وصف	*Country* or *Symptom_dp* or *Environmental_condition*	Literal
6	*image*	صورة	*Country* or *Symptom_dp*	Literal

Step 7: Define the Facets of the Slots

Slots have different facets that describe the value type, allowed values, the cardinality and other features of the values the Slots can take. In our case all of the slot values are string using UTF-8 (Arabic). For example, the value type of *name* property is String.

1) **Value type:** This describes the different types of values a property can take. The property *common_name* has the value type String.
2) **Allowed values:** This represents values allowed for different properties. The property *Image* has allowed values are *Country* and *Symptom_dp*.
3) **Cardinality:** A property can have single value or multiple values. Cardinality defines how many values a property can have. The property *common_name* has

multiple cardinality. It allows at least one value. Figure 4.3 show some data cardinality such as *common_name* and *name* minimum one literal.

Figure 4.4: Data cardinality

Step 8: Create instances of AgriDPalmOnto.

Adding instances (individuals) of classes in the ontology, creates a knowledge base. We use ontology to organize sets of instances. Since the number of instances in *AgriDPalmOnto* is quiet large when compared to the number of classes. The creation of individuals allows for all the properties of the classes to be recorded. The information of individuals is taken from a number of relevant research papers and documentations of date palm diseases domain.

In *AgriDPalmOnto*, we define around 264 instances that are representing all ontology concepts include (cases of diseases, diagnosis of diseases, pest and insect name , treatment name and others). An example of these instances is *Case_of_disease* witch contains 59 cases. Some of these cases is shown in Table 4.5. Also Figure 4.9 in Section 4.2.2 shows a number of individuals.

Table 4.5: Cases of disease instances example

Case	الحالة	Object property			
Instances		has_condition لديه ظروف بيئية	has_dangerous له خطورة	case_of حالة مرضية من	has_diagnosis لديه تشخيص مرضي
Case_1	حالة الإصابة بالآفة الحشرية - الحفار	Moderate_temp حرارة معتدلة High_temp حرارة عالية	High خطورة عالية	The_mole_cricket آفة الحفار	Diagnosis_1 تشخيص الإصابة بالآفة الحشرية - الحفار
Case_2	حالة الإصابة بالآفة الحشرية – النمل الأبيض	High_humidity رطوبة عالية	Medium متوسطة	Termites النمل الأبيض	Diagnosis_2 تشخيص الإصابة بالآفة الحشرية – النمل الأبيض

Step 9: Apply Ontology Reasoner

After creating instances**,** we apply an ontology reasoner (e.g. Pellet reasoner) on the ontology. This is necessary to identify new relations from existing ones. The reasoner is able to identify the different types of ontological relations such as transitive, symmetric, inverse and functional properties and use them to add new facts. More details and examples on using a reasoner are found in Section 4.2.3.

4.2 AgriDPalmOnto Implementation in Protégé OWL

Protégé is an open-source platform that provides a number of tools to construct domain models and knowledge-based applications with ontologies. Protégé can be customized to provide domain-friendly support for creating knowledge models and entering data [60]. This section describes the development of *AgriDPalmOnto* in protégé as an owl ontology.

4.2.1 Classes and Subclasses

Classes are the domain concepts and the building blocks of ontology (see Appendix A). In *AgriDPalmOnto*, *Pest*, *Country*, *DPalm*, *Diagnosis_of_disease*, *Case_of_disease*, *Treatment*, *Nutrient*, *Environmental_condition*, *Disease_dp*, *Degree_of_danger* and *Symptom_dp* are the subclasses of OWL:Thing. Figure 4.4 is a protégé snapshot of the class hierarchy in Arabic and English.

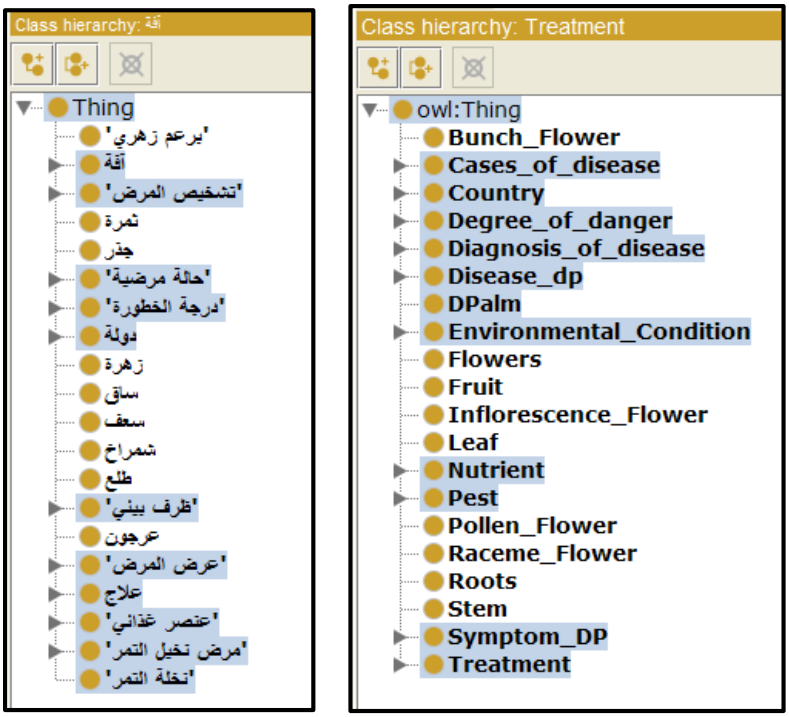

Figure 4.5: Top level AgriDPalmOnto taxonomy in Arabic and English

A class can have subclasses which represent the middle level Taxonomy. Figure 4.5 shows a taxonomy of *Animal_Pest* in Arabic and English. It has subclasses such as *Nematode_Pest, Mite_Pest, Microorganism_Pest, Insect_Pest, Bat_Pest, Bird_Pest, Rodent_Pest* and *Snail_Pest*.

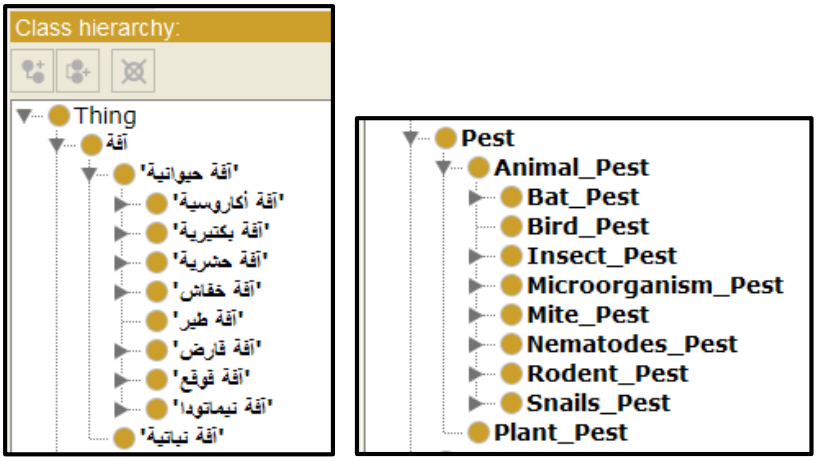

Figure 4.6: Middle level AgriDPalmOnto taxonomy in Arabic and English

4.2.2 Properties, Facets and Instances:

In *AgriDPalmOnto*, object property and data property are defined. Individuals are also defined in the ontology. Figure 4.7 shows data taxonomy such as *Stem* class which contains some instances. *Stem* is part of a palm tree belonging to the *Dpalm*. Data properties are show in Figure 4.8 which contains 6 properties, where the *name* and *common_name* are equivalent. These properties are explained as follows:

- *The name and common_name* 'اسم','اسم شائع': The *name* refers to the words of circulation of the disease in the world, especially in books and scientific journals, while a *common_name* is the name common among farmers and local community.
- *Scientific_name* 'اسم علمي': is very important because it allows people throughout the world to communicate unambiguously about diseases. These naming rules mean that every scientific name is unique.
- The *concentration* 'تركيز': refers to the amount of active ingredient from a chemical pesticide needs to be used to eradicate the disease or pest.
- The *description* 'وصف': expresses an event, activity or a note. For example, " *Appearance_36*" in diagnosis of disease contains descriptions " انحناء رأس النخلة وقد تؤدي الى موت النخلة اذا حدثت الاصابة بمنطقة التاج".
- The image 'صورة': is a representation of diseases or pests visually. Figure 4.6 shows the image of the red palm weevil.

Figure 4.7: Red palm weevil

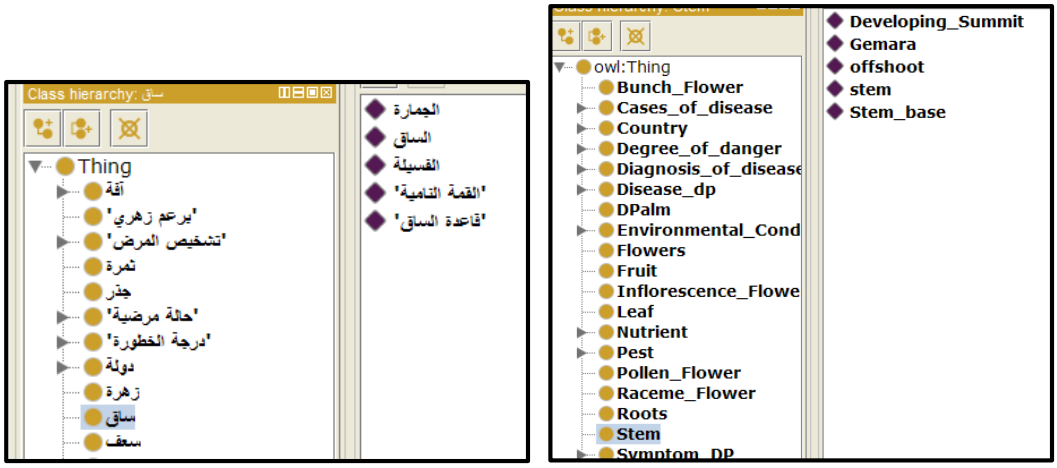

Figure 4.8: Instances of date taxonomy in Arabic and English

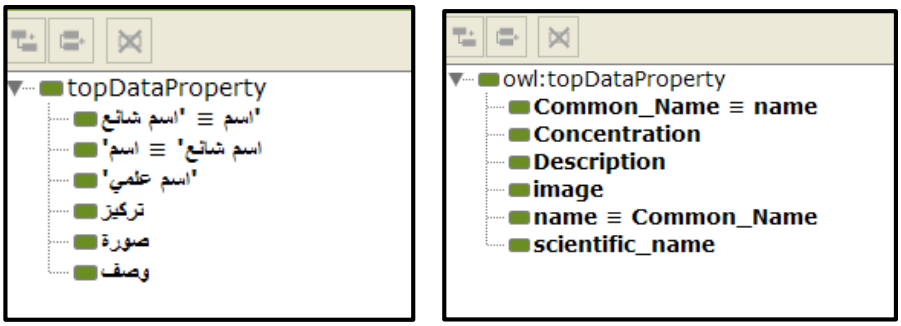

Figure 4.9: Data properties of date taxonomy in Arabic and English

Figure 4.9 shows the individuals in Protégé ontology editor. This tab contains class hierarchy, members list, object property, and data property.

The red palm weevil (*The_Red_Palm_weevil*). We use relations in object property such as *has_case*, *has_factor* , *has_treatment* and *widespread_in* properties.

Figure 4.10: Ontology Individuals for date palm pest of diseases

4.2.3 Run Reasoner:

When we run a reasoner and perform reasoning on the ontology, we get new or hidden knowledge utilized in the ontology.

Example 1: based on Figure 4.10, given the statement "*:Disease_dp :has_factor :Pest*", the reasoner will use the inverse property to add the following new fact: "*:Pest :factor_of : Disease_dp*".

Figure 4.31: Results of reasoner use inverse property

Example 2: the object property *similar_symptom* 'له نفس العرض' use the transitive and symmetric characteristic, *Appearance_15* 'تآكل في القمة النامية للنخلة يؤدي لموت النخلة' similar problem *Appearance_80* 'يلاحظ تدهور القمة النامية التي سرعان ما تنحني مع رأس النخلة وتموت جميعها وتنقصف الرأس وتنفصل عن الجذع' that led reasoner give new fact can show in Figure 4.11.

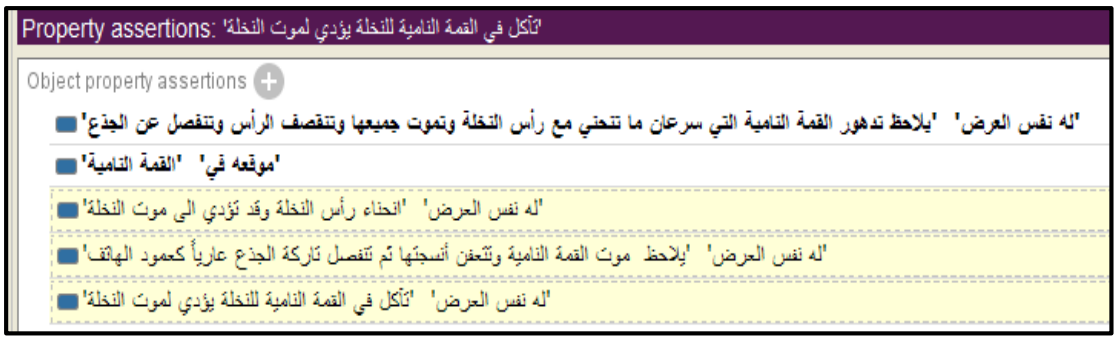

Figure 4.42: Results of reasoner use transitive and symmetric property

Example 3: show in Figure 4.12, given the statement "*:Appearance_72 :location_in :Leaf*" and object property *location_in* is functional and where *Appearance_69 location_in* 'موقعه في' *offshoot* 'الفسيلة' and *Leaf* 'السعفة', the reasoner will use the functional property to add the following new fact: "*:Appearance_72 :location_in :offshoot*".

Figure 4.53: Results of reasoner use functional property

4.2.4 Class Hierarchy in OWLVIz:

When using the OWLVIz plugin. Figure 4.13 shows the class hierarchy of the *AgriDPalmOnto*. This allows show of class hierarchy. Where it is divided into six main classes and each class contains subclass. For example, *Thing* contain *Treatment* 'علاج' that divided into two parts chemical treatment 'علاج كيميائي' and vital treatment ' علاج حيوي'.

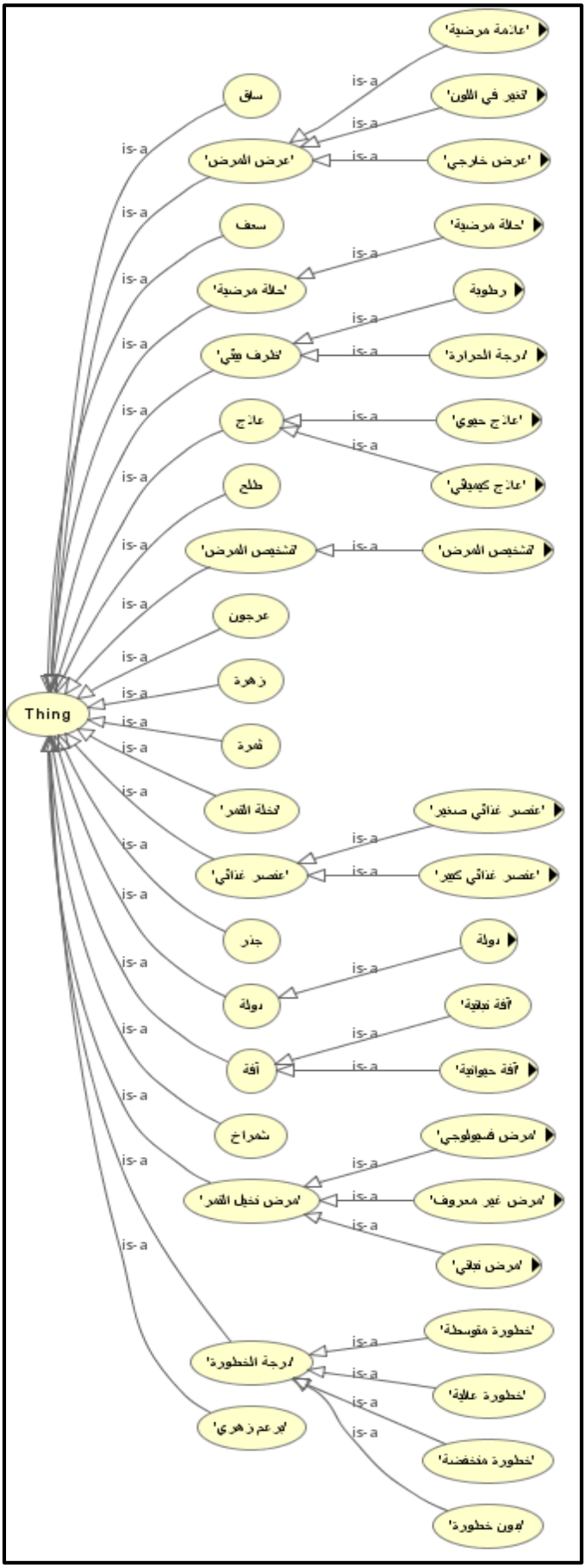

Figure 4.64: Class hierarchy of AgriDPalmOnto in Arabic

4.3 Evaluation of Coverage the AgriDPalmOnto

In this section, we evaluate the quality of the created ontology in representing all terms, properties, and relations through ontology querying. The evaluation of coverage approaches are explained shows in Section 3.3.2.2.

4.3.1 Quality Evaluation through the Red Palm weevil Disease Example

To evaluate the quality of the AgriDPalmOnto we choose a disease example to check if the ontology represent terms, properties and relations of disease sample. The chosen disease is *The_red_palm_weevil* 'سوسة النخيل الحمراء' pest in date palm. Figure 4.14 shows the terms, properties, and relations of disease that are represented in the ontology using Protégé. We note *The_red_palm_weevil* pest belongs to *insect_pest* which is part of *Insect_Pest* which is part of *Pest* and it has case of *Case_7* that belongs to *Case_of_disease*. It has *Condition_environment* high humidity, *has_dangerous* high and *has_diagnosis Diagnosis_7* that contains some symptoms. The pest *widespread_in* many Country, *has_treatment* some *Treatment* and *has_factor* unique pathogen.

The above example shows that the ontology represents all needed terms, concept, symptoms, Country, environmental conditions, treatment and other about red palm weevil disease. We can cite many such examples showing complete representation of the domain.

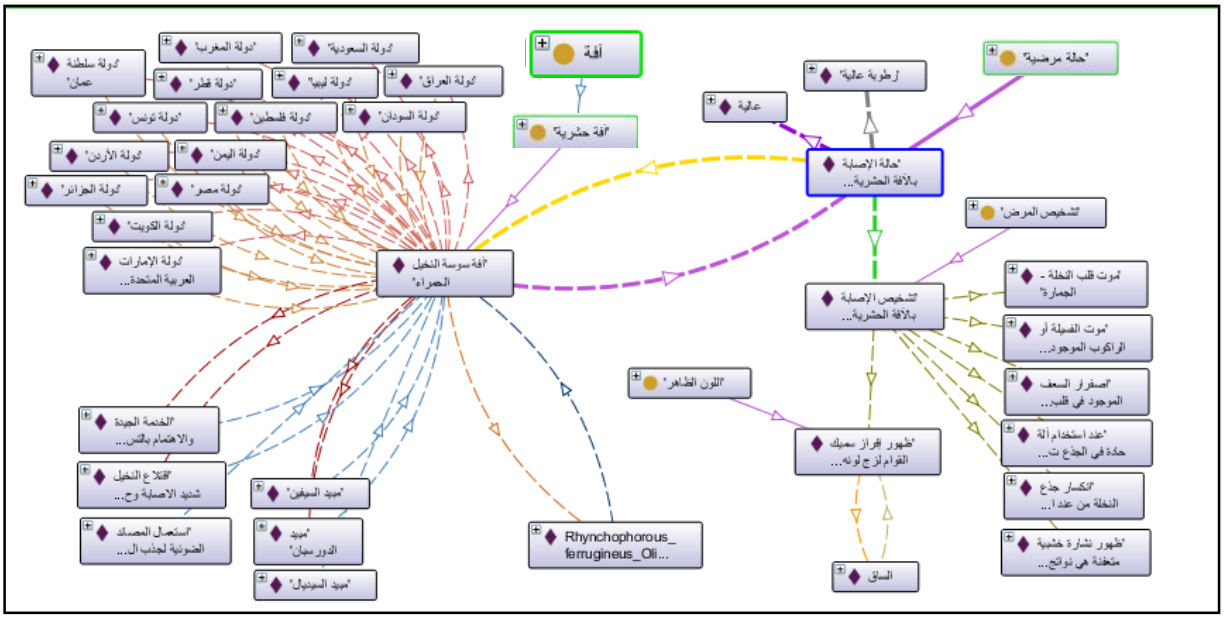

Figure 4.75: Ontology of the red palm weevil disease in Protégée

4.3.2 Quality Evaluation through Ontology Querying

In order to verify and validate the ontology in accordance to competency questions, we use the Description Logic Query (DL-Query) that is a standard Protégé plugin which is based on the Manchester OWL syntax. This allows the ontology to be accessed easily. This query function is an example of how *AgriDPalmOnto* system presented in Chapter 5 can use the *AgriDPalmOnto* ontology.

Three querying examples are presented next. They answer the main questions that are asked in the development process of the ontology (see section 4.1).

Example 1:

- The question: What are the common diseases in *Palestine* ?
- DL-Query: (*Plant_disease* and *widespread_in* value *Palestine*),('مرض نباتي' and 'منتشر في' value 'دولة فلسطين').
- The result of DL-Query is shown in Figure 4.15 which illustrates the individuals of diseases class that are common in the country Palestine.

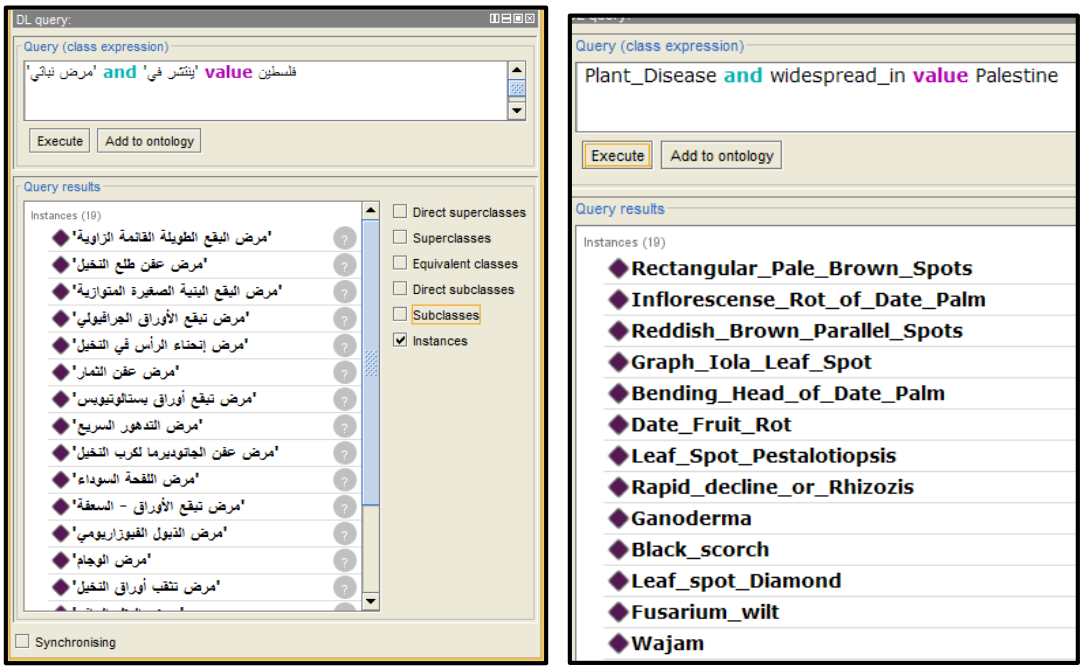

Figure 4.86: Query for common diseases in Palestine in Arabic and English

Example 2:

- The question: What is the diagnosis of disease specific symptoms *Appearance_93* or *Color_44* ?

symptom	Description
Appearance_93	تشاهد القواقع بالعين المجردة على شجرة النخيل وخاصة الساق والسعف
Color_44	تظهر خطوط صفراء على بعض سعف النخلة المصابة ثم تجف الأوراق ويحدث تشوه للسعف الحديث

- DL-Query: (*Diagnosis_of_disease* and *observed_problem* value *Appearance_93* or *observed_problem* value *Color_44*),('تشخيص المرض' and 'يلاحظ مشكلة في' value 'تشاهد القواقع بالعين المجردة على شجرة النخيل وخاصة الساق والسعف' or 'يلاحظ مشكلة في' value ' تظهر خطوط صفراء على بعض سعف النخلة المصابة ثم تجف الأوراق ويحدث تشوه للسعف الحديث').
- The result of DL-Query is shown in Figure 4.16 which illustrates the individuals of disease specific symptoms *Appearance_93* or *Color_44*.

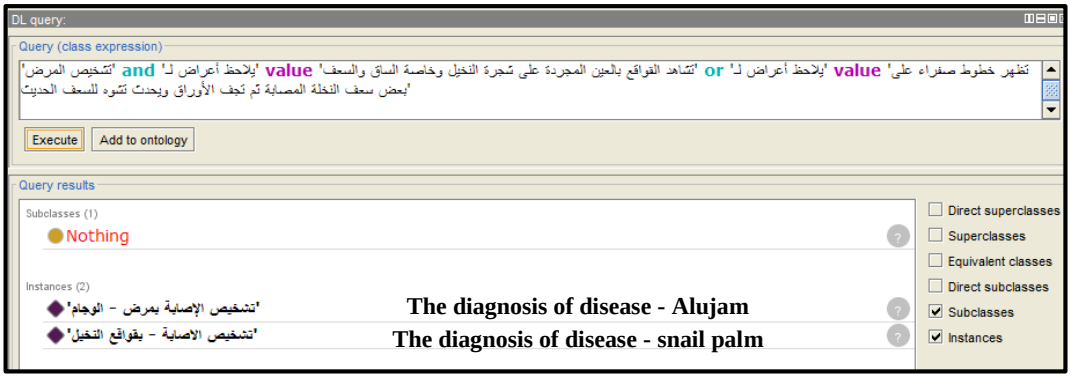

Figure 4.97: Query for diagnosis of disease specific symptoms

Example 3:

- The question: What is the appropriate chemical treatment for *The_Red_Palm_weevil* 'آفة سوسة النخيل الحمراء'?
- DL-Query: (*Chemical* and *treatment_of* value *The_red_palm_weevil*),(' مكافحة كيميائية' and 'يعالج من' value 'آفة سوسة النخيل الحمراء').
- The result of DL-Query is shown in figure 4.17 which illustrates the individuals of chemical treatment for *The_red_palm_weevil*. That means all these chemical pesticides used for treatment of the pest.

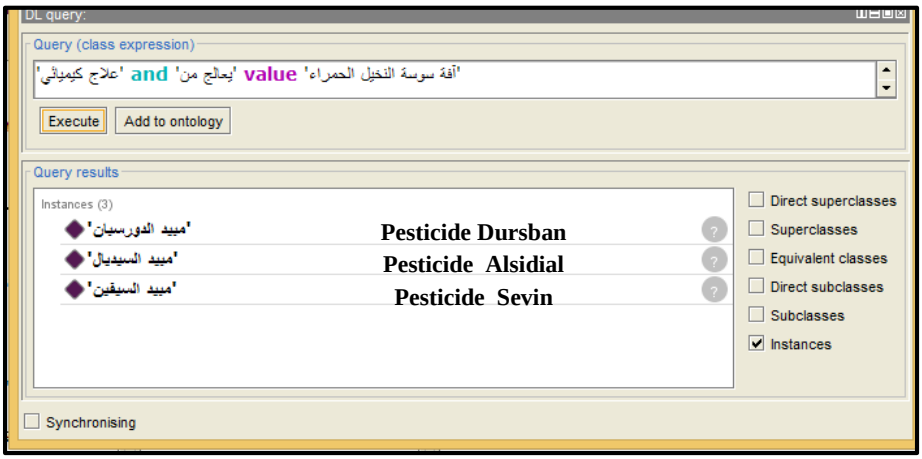

Figure 4.108: Query to determine appropriate chemical treatment for The_red_palm_weevil

Next, we present two examples using SPARQL query to stress the power of quality of ontology for answering previous questions.

Example 4:

- The question: What are the symptoms that appear on the *root* part in palm tree?
- SPARQL:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX
AgriDPOnto:<http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOnto#>
SELECT ?symptom ?description
        WHERE { AgriDPOnto:root    AgriDPOnto:has_symptom    ?symptom.
                ?symptom           rdfs:label                ?description. }
```

- The result of SPARQL-Query is shown in Figure 4.18 which illustrates the symptoms individuals that appear on the *root* part. That means all these symptoms *description* appear on the *root* of the palm tree part. The color sequence number refers to problem in palm parts that observed for change color but the appearance sequence number refers to problem in palm parts that observed for naked eye on abnormal phenomena.

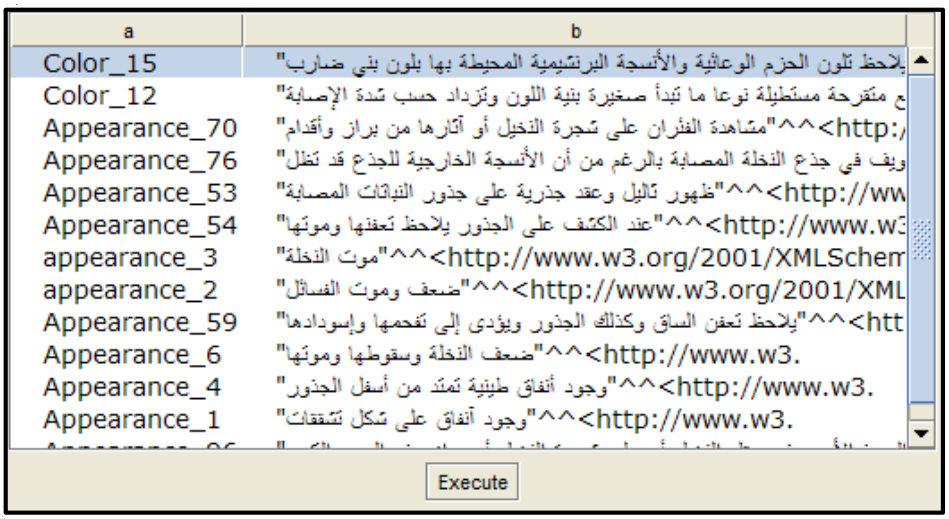

Figure 4.119: The individuals of symptoms that affected of part root

Example 5:

- The question: What is the relation of *Case_1* ,'الحفار - الحشرية بالآفة الإصابة حالة'?
- SPARQL: (we are use OPTIONAL because of the possibility of the lack of one case)

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOnto#>
SELECT  ?التشخيص ؟الخطورة ؟الحرارة ؟الافة
WHERE { AgriDPOnto:Case_1  AgriDPOnto:case_of  ?a.  ?a  rdfs:label  ?الافة.
      OPTIONAL { AgriDPOnto:Case_1  AgriDPOnto:has_condition  ?b.  ?b  rdfs:label  ?الحرارة }
      OPTIONAL { AgriDPOnto:Case_1  AgriDPOnto:has_diagnosis  ?d.  ?d  rdfs:label  ?التشخيص }
      OPTIONAL { AgriDPOnto:Case_1  AgriDPOnto:has_dangerous  ?c.  ?c  rdfs:label  ?الخطورة }}
```

- The result of SPARQL-Query is shown in Figure 4.19 which illustrates the individuals of relation of *Case_1*. That means all these properties are conditions ripe for injury case of the disease.

Figure 4.20: The individuals of relation of Case_1

4.4 Summary

In this chapter, we have explained the development and evaluation of the AgriDPalmOnto. We have explained the steps to build ontology. At the beginning, we identified the domain and scope of the ontology. Then we defined the terms and the properties. We have used the ontology development protégé owl to implement and realize the ontology. We have added individuals to *AgriDPalmOnto* ontology (i.e. creating knowledge base) and explained some of the factors that are related to the values of some properties. Then we have presented an evaluation of the AgriDPalmOnto and proved that the ontology have answered all questions and returns the correct results. The results of the evaluation show that the AgriDPalmOnto ontology reflects the intended data palm diseases domain.

Chapter 5
The AgriDPalmOnto Approach

In this chapter, we present in detail the realization of the proposed *AgriDPalmOnto* approach for diagnosing date palm diseases. The development of the approach consists of two phases: system analysis and system design.

5.1 System Analysis

In this section, we present a complete description of the behavior of *AgriDPalmOnto* system including a set of use cases that describe interactions, functional requirements and nonfunctional requirements, which impose constraints on the design and implementation.

5.1.1 System Description

We develop an approach for the ontology-based diagnosis of date palm diseases that automatically generates suggested diagnosis of diseases through determination of symptoms of the disease. It is based on the *AgriDPalmOnto* and its knowledge base to produce the suggested diagnosis. To satisfy this goal we divide the system into the following two components:

1. **Web Application:** allows the user to perform a number of operations related to the diagnosis of date palm diseases: such as search for diseases, pests, diagnosis, treatment and show the results of diagnosis of date palm diseases and related details. This component depends on the *AgriDPalmOnto* knowledge base (developed in Chapter 4) for performing its functionality. It uses the ontology through querying and reasoning.
2. **AgriDPalmOnto Knowledge Base:** an ontology enriched with individuals (instance) containing disease descriptions, symptoms and information that is needed in the process of diagnosis of date palm diseases.

5.1.2 System Functions

We present high-level system functions and requirements by use cases and description of functionality, which contain primarily actors and use cases. Actors are entities that interact with the systems, while use cases are the system functions actors involve. The *AgriDPalmOnto* system supports the following use cases:

Table 5.1 System use cases

Use Case	Actor	Use Case No.
Display the disease or pest information by browsing	Agricultural engineer or Farmers or Agricultural guide	1
Display the disease or pest information by searching		2
Choose the approach of diagnosis of date palm diseases		3
Choose the country in which he resides		4
Choose the infected part of the tree disease		5
Choose the symptoms to determine the diagnosis of date palm diseases		6

Display the diagnosis of disease or pest information by browsing		7
Display the diagnosis of disease or pest information by search		8
Display the pathogen and treatment of disease or pest information by browsing		9
Display the pathogen and treatment of disease or pest information by search		10
Display the case of disease or pest information by browsing		11
Display the case of disease or pest information by search		12
Send disease data is not available in the system		13

- **User Characteristics:** The user should be familiar with the *AgriDPalmOnto* terminology respectively with diseases terminology.
- **Principal Actors:** The two principal actors in *AgriDPalmOnto* are the agricultural engineer or farmers or agricultural guide.

5.1.3 Specific Requirements

This section presents specific requirements of *AgriDPalmOnto* that covers its various functions.

- **Functional Requirements**:
  - The system shall enable the agricultural engineer or farmers to display the disease or pest information by browsing.
  - The system shall enable the agricultural engineer or farmers to display the disease or pest information by searching.
  - The system shall enable the agricultural engineer or farmers to choose the approach of diagnosis of date palm diseases
  - The system shall enable the agricultural engineer or farmers to choose the country in which he resides.
  - The system shall enable the agricultural engineer or farmers to choose the infected part of the tree disease
  - The system shall enable the agricultural engineer or farmers to choose the symptoms to determine the diagnosis of date palm diseases
  - The system shall enable the agricultural engineer or farmers to display the diagnosis of disease or pest information by browsing
  - The system shall enable the agricultural engineer or farmers to display the diagnosis of disease or pest information by search
  - The system shall enable the agricultural engineer or farmers to display the pathogen and treatment of disease or pest information by browsing
  - The system shall enable the agricultural engineer or farmers to display the pathogen and treatment of disease or pest information by search.
  - The system shall enable the agricultural engineer or farmers to display the case of disease or pest information by browsing.
  - The system shall enable the agricultural engineer or farmers to display the case of disease or pest information by search.

- The system shall enable the agricultural engineer or farmers to send disease data is not available in the system.

We describe each functional requirement by giving various use cases that define interactions between a role and AgriDPalmOnto system.

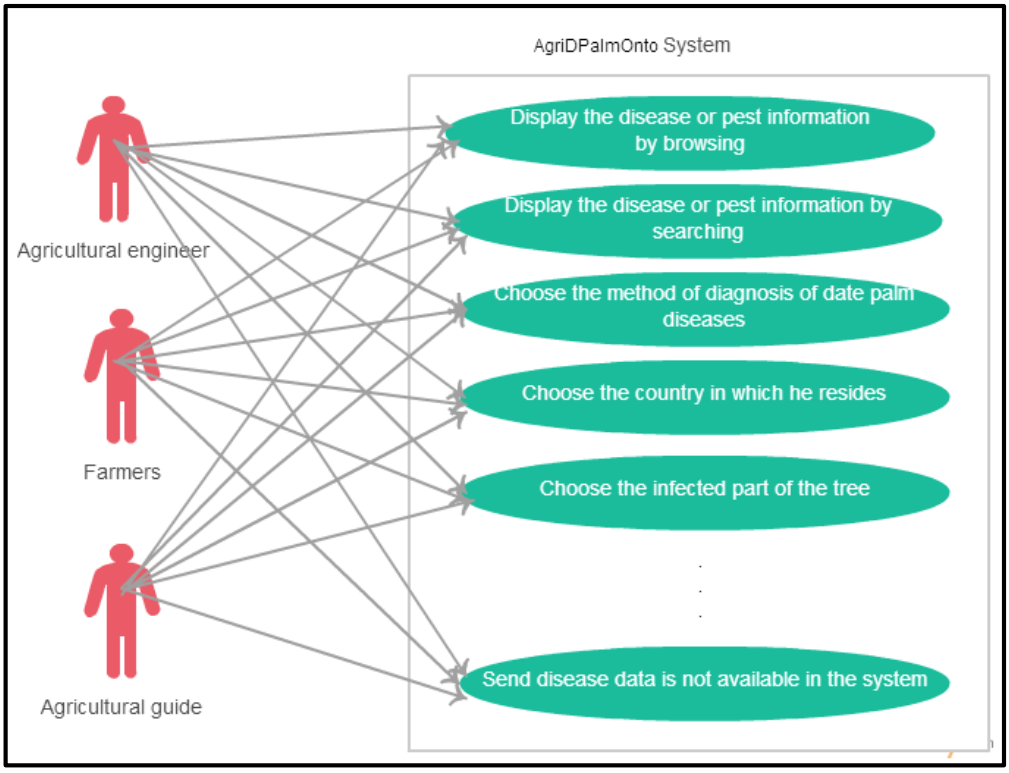

Figure 5.1 Use cases of users

Use Case 1: Display the disease or pest information by browsing.

Primary Actor	Agricultural engineer or Farmer or Agricultural guide (User)
Main Scenario	1. User clicks on the disease or pest image. 2. System displays the disease or pest information and definition. 3. User can clicks on more detail about disease or pest.
Alternate Scenario	1. User clicks on the date palm disease icon. 2. System displays all diseases and pests by category. 3. User clicks on the disease or pest. 4. System displays the disease or pest information and definition. 5. User can clicks on more detail about disease or pest.

Use Case 2: Display the disease or pest information by searching.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the search icon in menu and add name of disease or pest in box. 2. System displays the names of diseases or pests. 3. User clicks on special disease or pest. 4. System displays the disease or pest information and definition.

Use Case 3: Choose the approach of diagnosis of date palm diseases.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on specified approach.

Use Case 5: Choose the country in which he resides.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by country approach.

Use Case 5: Choose the infected part of the tree disease.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by palm tree parts approach. 4. User Choose the infected part of the tree disease.

Use Case 6: Choose the symptoms to determine the diagnosis of date palm diseases.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by palm tree parts approach. 4. User Chooses the infected part of the tree disease. 5. System displays the symptoms that appeared in this part. 6. User Chooses the symptoms to determine the diagnosis of date palm diseases
Alternate Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by country approach. 4. User Chooses the problem of the tree disease. 5. System displays the symptoms that appeared in this problem. 6. User Choose the symptoms to determine the diagnosis of date palm diseases

Use Case 7: Display the diagnosis of disease or pest information by browsing.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu.

	2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by palm tree parts approach. 4. User Chooses the infected part of the tree disease. 5. System displays the symptoms that appeared in this part. 6. User Chooses the symptoms to determine the diagnosis of date palm diseases. 7. System displays the diagnosis of disease or pest.
Alternate Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by country approach. 4. User Chooses the problem of the tree disease. 5. System displays the symptoms that appeared in this problem. 6. User Chooses the symptoms to determine the diagnosis of date palm diseases 7. System displays the diagnosis of disease or pest

Use Case 8: Display the diagnosis of disease or pest information by search.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the search icon in menu and add name diagnosis of disease or pest in box. 2. System displays the names diagnosis of diseases or pests. 3. User clicks on special diagnosis . 4. System displays the diagnosis of disease or pest information.

Use Case 9: Display the pathogen and treatment of disease or pest information by browsing.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by palm tree parts approach. 4. User Chooses the infected part of the tree disease. 5. System displays the symptoms that appeared in this part. 6. User Choose the symptoms to determine the diagnosis of date palm diseases. 7. System displays the diagnosis of disease or pest. 8. User Chooses the case of disease or pest then choose the disease or pest. 9. System displays the pathogen and treatment of disease or pest information.
Alternate Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by country approach. 4. User Chooses the problem of the tree disease.

	5. System displays the symptoms that appeared in this problem. 6. User Choose the symptoms to determine the diagnosis of date palm diseases 7. System displays the diagnosis of disease or pest. 8. User Chooses the case of disease or pest then choose the disease or pest. 9. System displays the pathogen and treatment of disease or pest information.
Alternate Scenario	1. User clicks on the disease or pest image. 2. System displays the disease or pest information and definition. 3. User can clicks on more detail about disease or pest. 4. System displays the pathogen and treatment of disease or pest information.
Alternate Scenario	1. User clicks on the date palm disease icon. 2. System displays all diseases and pests by category. 3. User clicks on the disease or pest. 5. System displays the disease or pest information and definition. 6. User can clicks on more detail about disease or pest. 7. System displays the pathogen and treatment of disease or pest information.

Use Case 10: Display the pathogen and treatment of disease or pest information by search.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the search icon in menu and add name case of disease or pest in box. 2. System displays the names cases of diseases or pests. 3. User clicks on special case. 4. System displays the pathogen and treatment of disease or pest information .

Use Case 11: Display the case of disease or pest information by browsing.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by palm tree parts approach. 4. User Chooses the infected part of the tree disease. 5. System displays the symptoms that appeared in this part. 6. User Chooses the symptoms to determine the diagnosis of date palm diseases. 7. System displays the diagnosis of disease or pest. 8. User Choose the case of disease or pest. 9. System displays the case of disease or pest information.
Alternate Scenario	1. User clicks on the diagnosing disease icon in menu. 2. System displays the approaches of diagnosis of date palm diseases. 3. User clicks on diagnosing of date palm diseases by country approach.

	4. User Chooses the problem of the tree disease. 5. System displays the symptoms that appeared in this problem. 6. User Chooses the symptoms to determine the diagnosis of date palm diseases 7. System displays the diagnosis of disease or pest. 8. User Chooses the case of disease or pest then choose the disease or pest. 9. System displays the case of disease or pest information.

Use Case 12: Display the case of disease or pest information by search.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the search icon in menu and add name case of disease or pest in box. 2. System displays the names cases of diseases or pests. 3. User clicks on special case. 4. System displays the case of disease or pest information.

Use Case 13: Send disease data is not available in the system.

Primary Actor	Agricultural engineer or Farmers or Agricultural guide (User)
Main Scenario	1. User clicks on the search icon in menu and add name case of disease or pest in box. 2. System displays the names cases of diseases or pests. 3. User clicks on special case. 4. System displays the case of disease or pest information.

- **Nonfunctional Requirements:**
  1. Accessibility: The system is deployed as a Web-Based application that allows the user to access it online without restriction.
  2. Response Time: the system shall execute user requests in short time. This is represented in response time for diagnosing of date palm diseases compared with manual diagnosis, and taking accuracy into consideration.

5.2 System Structure

AgriDPalmOnto system in Figure 5.2 contains four basic modules namely; the *diagnosis* module, the *pathogenesis* module, the *treatment recommendation* module and the *querying engine inference* module.

- In order to detect palm disease, we provide the plant's signs and symptoms to the *diagnosis* module, which detects what type of disease in plant by referring to the ontology and performing the required queries and reasoning.
- Once the type of the disease is determined, the *pathogenesis* module finds the current stage of the plant based on the disease type and the signs and symptoms provided by the user based on the knowledge base and performing the required queries and reasoning.
- Based on the determined disease type and disease stage, the *treatment recommendation* module can recommend a specific treatment for the case at hand by referring to the knowledge base and performing the required queries and reasoning.

The three modules interact with the knowledge base through the *querying engine inference* module using SPARQL quires. The knowledge base will describes the different types of date palm diseases in detail. Each disease is described in terms of its structure, signs and symptoms, danger and treatment.

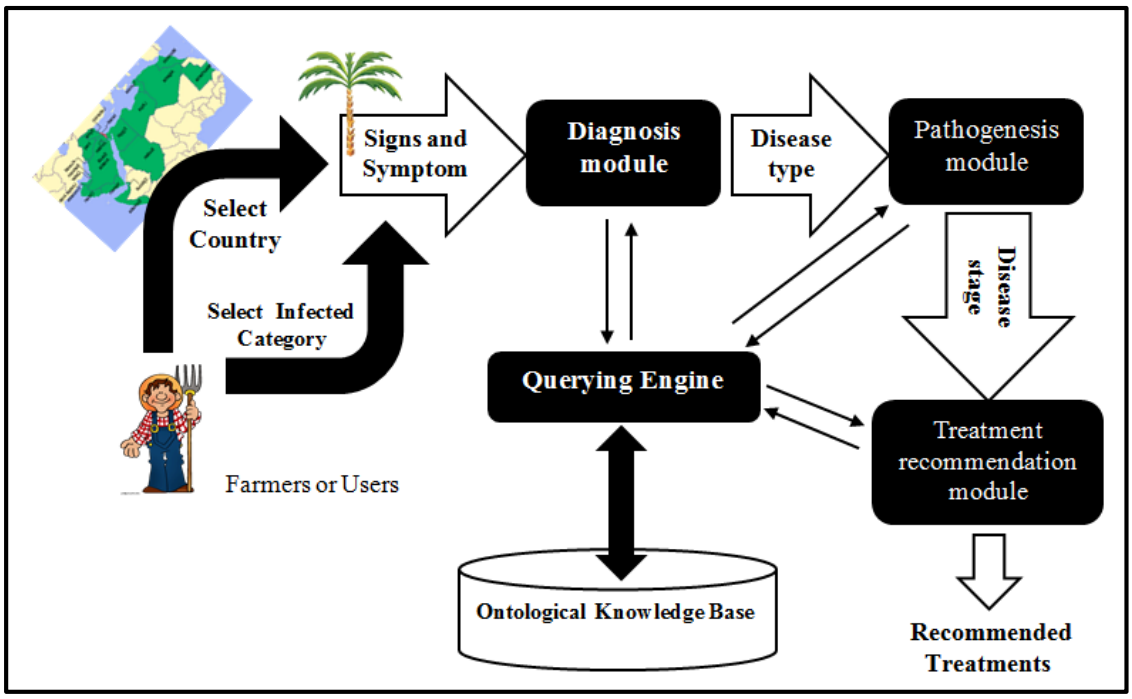

Figure 5.2 AgriDPalmOnto system structure

The flow diagram in Figure 5.3 shows the process conducted by the system in diagnosing a disease. It enables the user to select a country where a disease is common or select the infected category, i.e. *Root_system* 'المجموع الجذري' or *Shoot_system* 'المجموع الخضري', which allows the user to give more details such as determining a private problem tree or select specialist palm tree part.

Then the user can select initial symptoms that appears in the selected part or category. In this stage the system displays the suggested diagnosis of the disease. At the end, the system returns symptom, case, pathogen, treatment of selected specialist diagnosis.

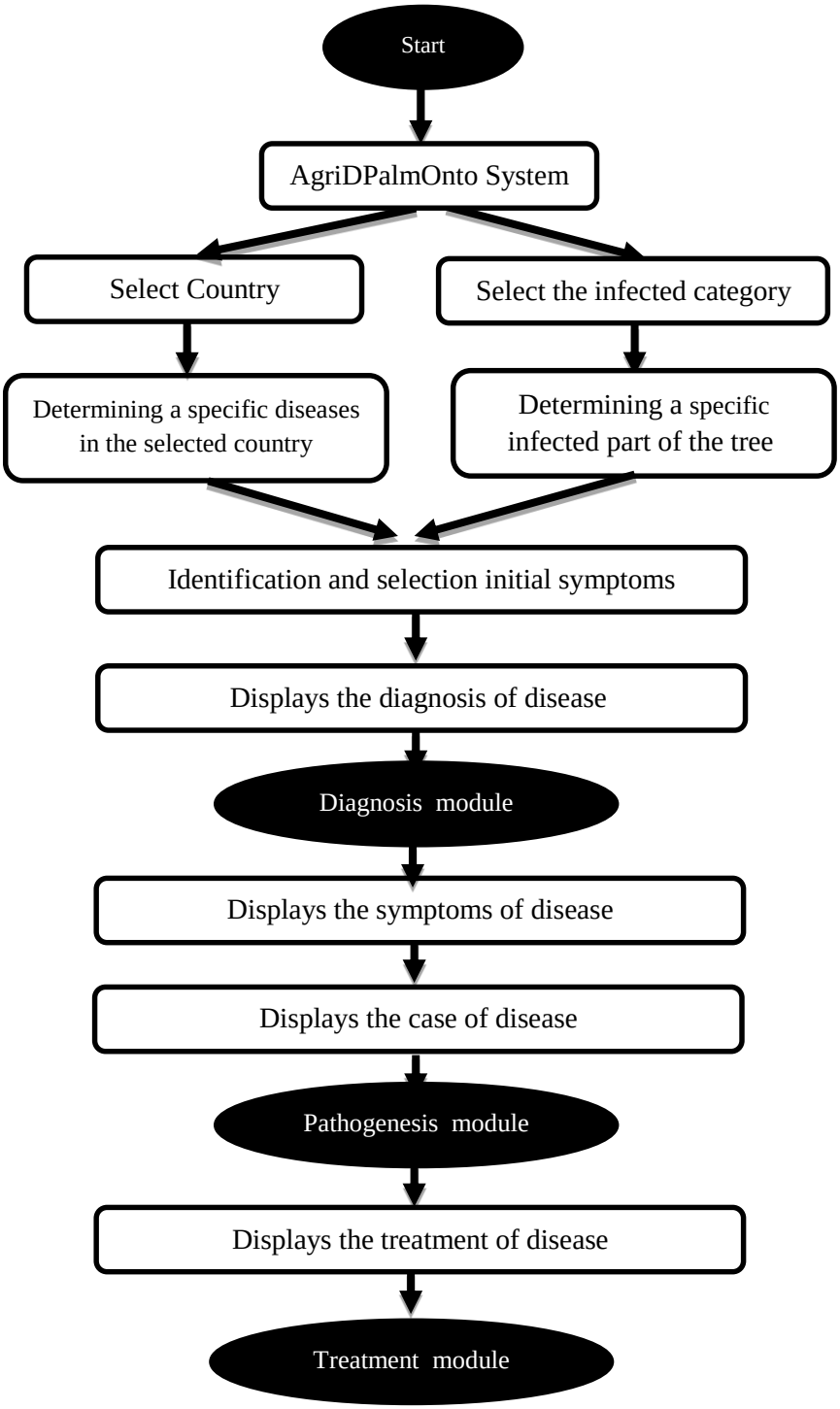

Figure 5.3 Stages of the diagnosis process

5.3 System Design

The requirements identified in the system analysis phase are transformed into a system design that can be used as an input to system implementation.

Figure 5.4 shows the components of *AgriDPalmOnto* system and the dependencies and interactions between them.

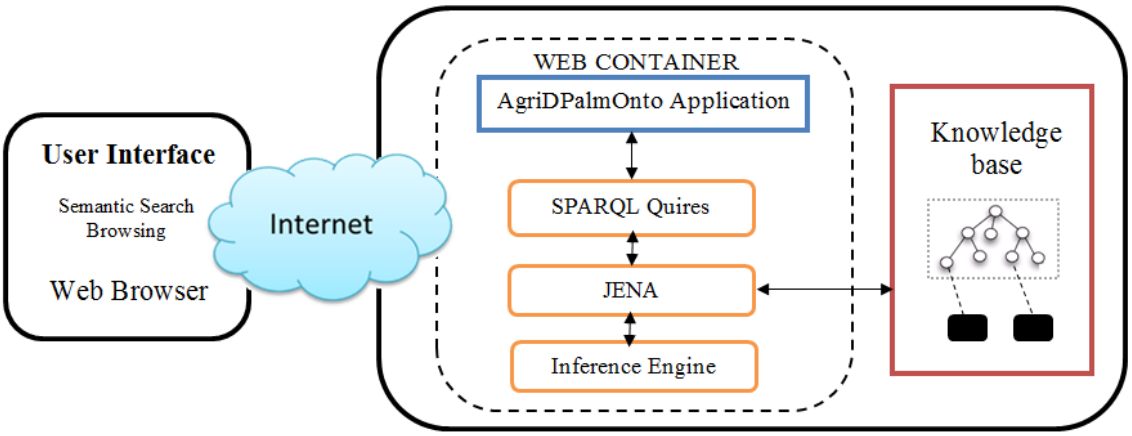

Figure 5.4 Components of AgriDPalmOnto system

The system is designed keep user access easy and convenient. Most interaction is performed through simple forms, checkboxes and radio buttons. Some of the basic features such as disease diagnosis and pest diagnosis are available to users through direct links.

The system is based on the n-tier model of web applications. This model allows the different components of the system to be built by various experts, specializing in its own domain. Each component of the system can exist on different machine on the web. Knowledge base and inference engine are the two most important components of the system.

- **The Knowledge Base (KB):** The knowledge base is built using OWL ontology. It consists of the ontology and enriched with individuals related to date palm diseases and pests for example red palm weevil 'سوسة النخيل الحمراء' and more presented in Section 3.2.6.

  AgriDPalmOnto ontology contains all diseases and pest in Arabic world information and the relation between them and symptoms, pathogen, treatment and environmental condition. It is used to identify the disease's and pest name, common name, pathogen, spread and information that is needed in the process of diagnosis the disease. We explained the design of *AgriDPalmOnto* ontology in Chapter 4: (AgriDPalmOnto Ontology Development).
- **The Inference Engine:** The inference engine accepts user input queries and responses to questions through the I/O interface and uses this dynamic information together with the static knowledge stored in the knowledge base. The knowledge in the knowledge base is used to derive conclusions about the current case or situation as presented by the user's input. JENA is used here for this purpose.
- **Server Side Application (SSA):** Application is built using Java Server Pages (JSP) and Servlet. The JSP provides the web developers with a framework to create dynamic content on the server using HTML, XML, Java classes, which is secure, fast and independent of server platform.
- **User Web Interface:** This interface allows a user to search and explore diseases or pest information and chooses among them as disease symptoms in order to get diagnosis from the system.

Figure 5.5 shows the user interface, which contain five parts: searching, diagnosing of date palm diseases, definition of date palm tree, choosing disease or pest and possibility of users to add information about symptoms or diseases or pests are not available in the system.

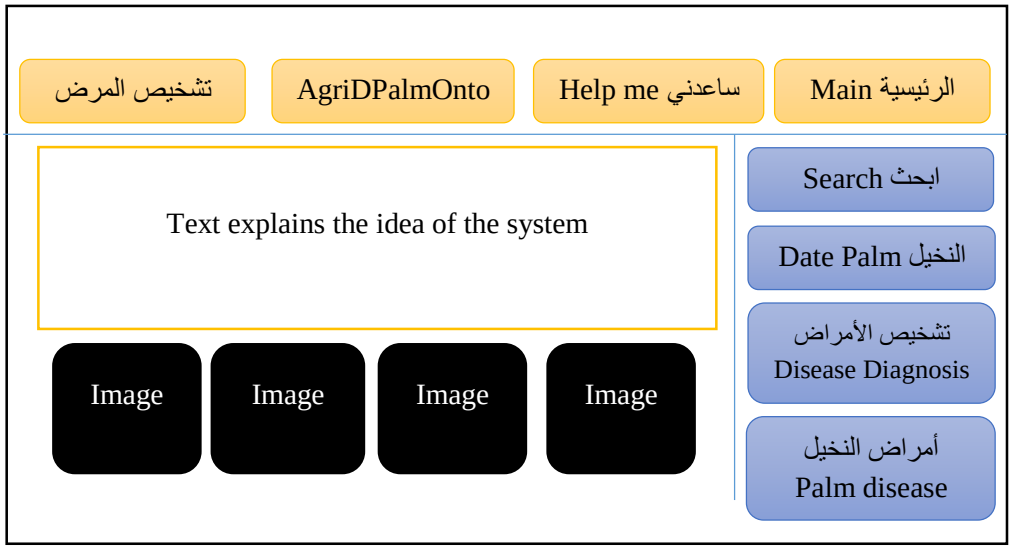

Figure 5.5 User interface searching and exploring disease or pest information

In addition, the interface is used to display the results of diagnoses and related information to the user. This might include the case, diagnosis, entry symptoms, treatment and pathogen information about specialist disease or pest.

The system starts working once the user chooses any link from the user web interface. This request is directed to process by *AgriDPalmOnto* ontology to get information about diseases or pests.

AgriDPalmOnto Deployment: Figure 5.6 describes the static deployment of *AgriDPalmOnto* system consisting of nodes and their relationships. It needs one server (the Web Server) which contains the *AgriDPalmOnto* system and the *AgriDPalmOnto* knowledge base. The user uses his browser to interact with the system.

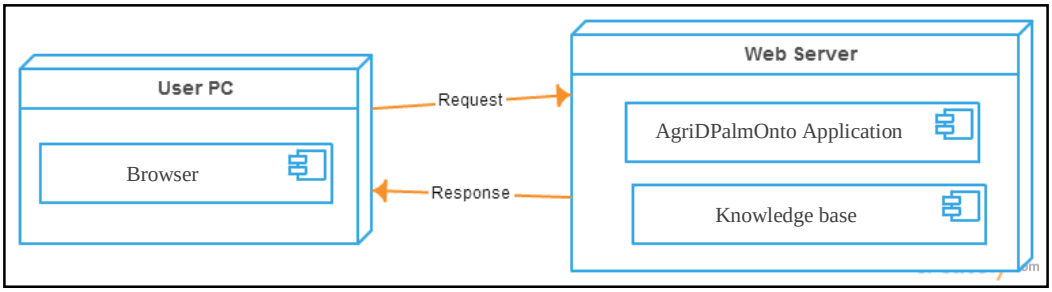

Figure 5.6 Deployment Diagram of AgriDPalmOnto

Figure 5.7 shows how one processes of *AgriDPalmOnto* operate with one another and in what order and shows object (user, system and knowledge base) interactions arranged in time sequence. It depicts the sequence of messages exchanged between the objects to carry out the functionality of the scenario. The sequence diagram presents the main use case (use case in in section 5.1.3) in the *AgriDPalmOnto* system that refer the disease diagnosis.

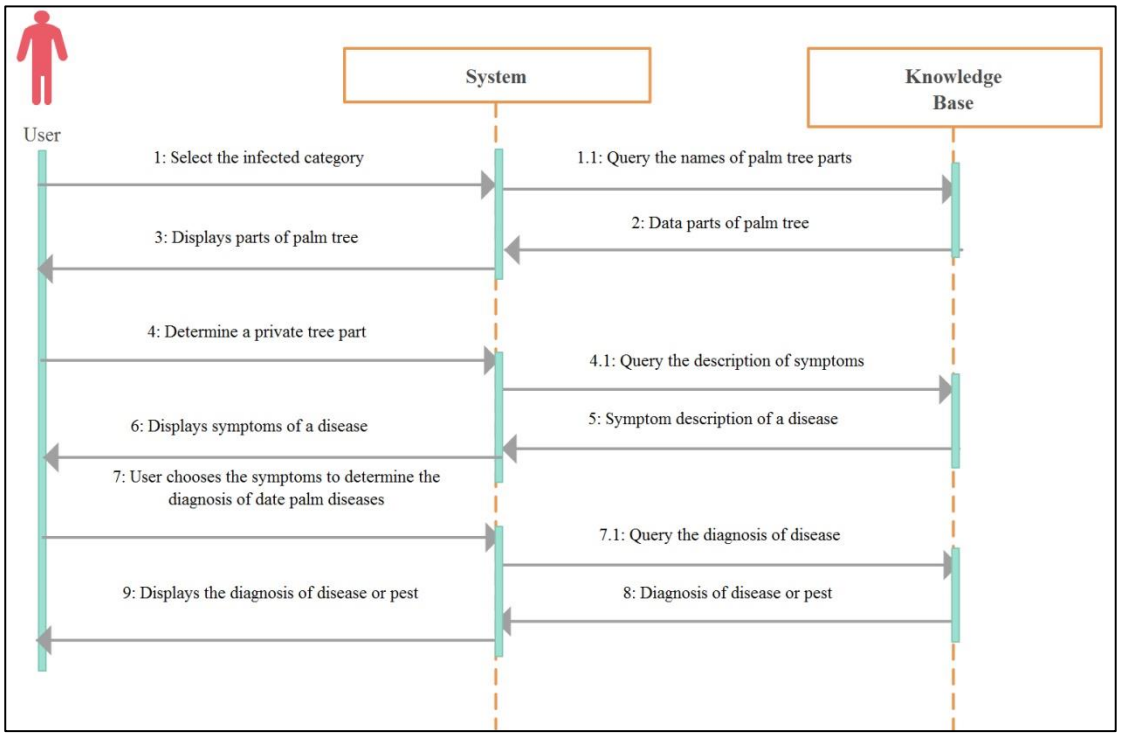

Figure 5.7 Disease Diagnosis

5.4 Summary

In this chapter, we have presented the phases of building the *AgriDPalmOnto* system. It consists of the following two phases:

In the analysis phase, we analyzed and specified the requirements of the system and divided the system into two components: web application, *AgriDPalmOnto* knowledge base. We also described the functionality of the system through the use cases. Then we explained the *AgriDPalmOnto* process through flowchart of sequence activities with interleaving decision points as shown in Figure 5.3.

In the design phase, we explained the interaction and dependencies between these three components in the *AgriDPalmOnto* architecture (Figure 5.2). Then we explained in details the design of these four components. Then we explained how the *AgriDPalmOnto* system inters operates at high level and how processes of *AgriDPalmOnto* operate with one another.

Chapter 6
System Implementation

In this chapter, we present how the *AgriDPalmOnto* system is implemented according to the design of *AgriDPalmOnto* system presented in Section 5.3 (System Design). The implementation is realized through two parts: the knowledge base and the *AgriDPalmOnto* system.

The knowledge base is the main part used by the system and contains the *AgriDPalmOnto* ontology together with the individuals enriching the ontology. The *AgriDPalmOnto* system contains five components (realized as menu items) that are: view hierarchical *AgriDPalmOnto* ontology, query for diseases, diagnosing date palm diseases, view date palm information and semantic search.

We use JSP and Servlet technology for building the front end application which is connected to the modules of the system and ontological knowledge base.

6.1 The system AgriDPalmOnto Knowledge Base

The knowledge base is stored in *AgriDPalmOnto* web server and accessed by the system using OWL API when the system needs to get the information of diseases and pests. We explain the developments and implementation of *AgriDPalmOnto* ontology using Protégé in Section 4.1 (AgriDPalmOnto Development).

6.2 User Web Interface Realization

This component is implemented using JSP and Servlet. Servlet is connected to *AgriDPalmOnto* ontology that contains diseases and pests. It allows the user to diagnosis and search through these data. This would enable the user to choose the symptoms to determine correct diagnosis. The data will be loaded upon user request in very small HTTP requests. Figure 6.1 shows the user interface.

The design of the user web interface presented in Section 5.3 illustrate that the user interface contain five parts. First part is for searching. The second part for choosing symptoms to diagnosis of diseases. The third part for a list of diseases and pests. The fourth part for structural building ontology. In the implementation of this interface we create a web page that contains the fourth parts.

The implementation of the semantic searching includes searching in knowledge base using any word in Arabic language.

Figure 6.1: Main page

In addition, the design of the output interface contains the diseases and pests information, name, description, image, symptoms, pathogen and treatment. The implemented parts are reflected in the web page shown in Figure 6.2 that present name, image and description of the pest *Dust_mite* 'آفة حلم الغبار' and Figure 6.3 present common name, pathogen and treatment.

Figure 6.2: Image of Dust mite pest on the interface

Figure 6.3: Details of the Dust mite pest

Next, we present the details of semantic search part specifically process of search about pests and diseases.

6.3 Search Reasoning

The search engine allows one to ask for content meeting specific criteria (typically those containing a given word or phrase) and retrieves a list of items that match those criteria [61]. RDF and the Web Ontology Language (OWL) which are ontology based procedures or representing knowledge on the Web, introduce aspects beyond those used in ordinary XML, allowing users to define terms (for example, classes and properties), express relationships among them, and assert constraints and axioms that hold for well-formed data. An application of the emerging Semantic Web is a Semantic Web search engine which searches the Semantic Web documents against a user query for accurate results. Our work uses RDF Semantic Web documents which are searched in response to a user query for exact results.

In our approach the domain date palm diseases ontology based search part is developed as an application where each module have been developed using java. A user interface is also developed as part of the *AgriDPalmOnto* system where the user enters his query for search. Some screenshots of the user interface containing the search query and its results are shown in Figure 6.5 and Figure 6.6.

Figure 6.4: Semantic search for diagnosis of palm weevil

Figure 6.4 shows the search interface so that the user can write any query in Arabic language. For example when we add word search diagnosis palm weevil " تشخيص سوسة النخيل" in Arabic. Result is presented correctly where they were retrieving relevant information search, the search process through label in ontology contain two words "تشخيص" and "سوسة النخيل", then when clicks in the apparent link that is shown in Figure 6.5, the system performs a query about the symptoms of the disease shown in Figure 6.6. The same result is shown when using word "أعراض" that equivalent to the word "تشخيص".

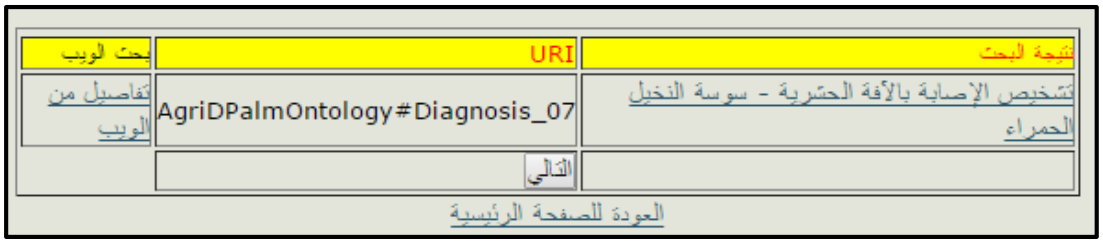

Figure 6.5: Search result for diagnosis palm weevil in Arabic

Figure 6.6: Diagnosis red palm weevil

In another example, when a user queries about case of a particular disease and does not know the full name of a disease like put among the following search "حالة خنفساء" that shown in Figure 6.7. The result is shown in Figure 6.8 that is present in all cases of diseases that contain name "خنفساء". When selecting any one such as *Case_21* " حالة الإصابة بالآفة الحشرية – الخنفساء ذات الصدر المنشاري", it will return the details shown in Figure 6.9.

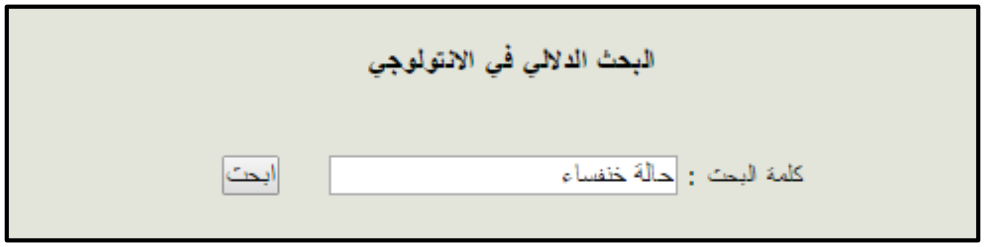

Figure 6.7: Semantic search for case beetle in Arabic

Figure 6.8: Result of searchimg for case beetle in Arabic

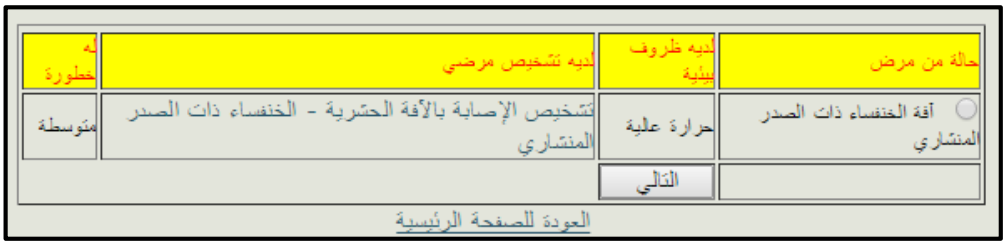

Figure 6.9 Result of case_21"حالة الإصابة بالآفة الحشرية – الخنفساء ذات الصدر المنشاري"

In a clear example of expressing the concept of semantic search and its importance in information retrieval, when we search for bast pest "آفة اللحاء", as shown in Figure 6.10, which is common to pest of the name Bark Beetle "آفة خنفساء القلف" results show the pest intended *Name* that as shown in Figure 6.11.

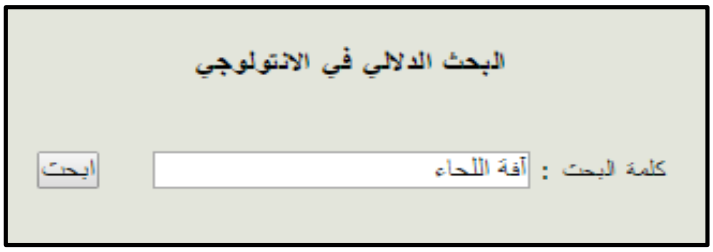

Figure 6.10: Semantic search about bast pest

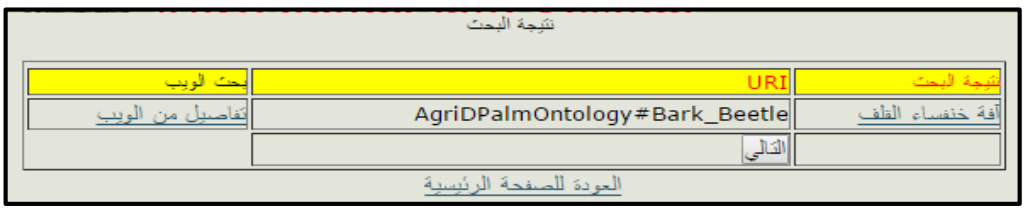

Figure 6.11: Result search about bast pest in Arabic

When selecting the result search "آفة خنفساء القلف" then is presenting more details about this pest that as shown in Figure 6.12.

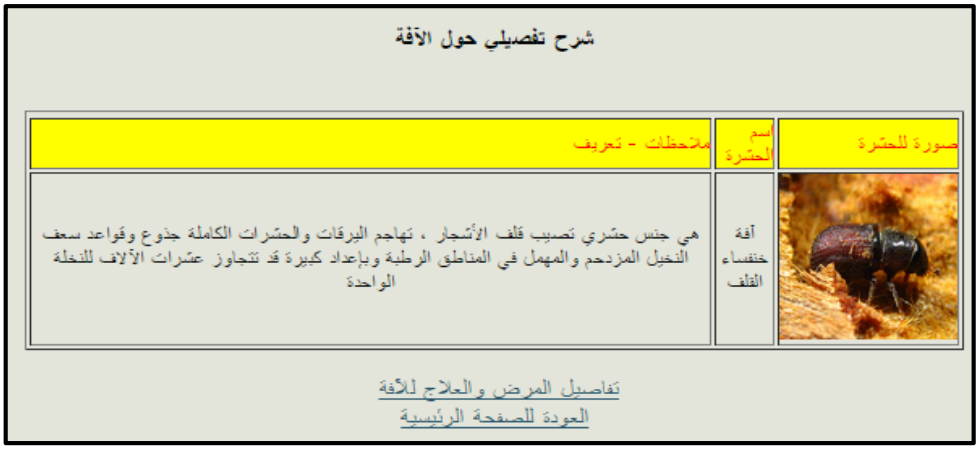

Figure 6.12: Result of bark beetle past information

6.4 Diagnosis of Diseases

This component is the core of *AgriDPalmOnto* system as illustrated in the system architecture (Section 5.2). The *AgriDPalmOnto* knowledge base plays the major role in system where it stores the knowledge about diseases, pests, treatment, pathogen and symptoms as illustrated in Section 4.1 (AgriDPalmOnto Development). A Java entity classes is implemented to realize and hold the data retrieved from the ontology. Classes are shown in Table 6.1.

Table 6.1: Classes in AgriDPalmOnto system

Class name in Java	Name in Arabic	Description
Country	استرجاع الدول	is responsible for determining the country.
AgriSelect	نوع الأعراض	is responsible for determining type of symptom.
Symptom	الأعراض الظاهرة	is responsible for determining specified symptom that are shown in palm parts.
Diagnosis	تشخيص المرض	is responsible for diagnosing of disease depending on the specific symptoms in the previous step.
Problem	الأعراض النهائية للمرض	is responsible for representing all symptoms that appear in case of previously defined disease.
Case	حالة المرض والظروف البيئية	is responsible for viewing the status of the disease and environmental conditions Information
Pest	تفاصيل المرض والعلاج	is responsible for showing disease information and details appropriate treatment

Figure 6.13 depicts the class diagram of *AgriDPalmOnto* system by showing the main classes, their attributes, operations (or methods), and the relationships among these classes.

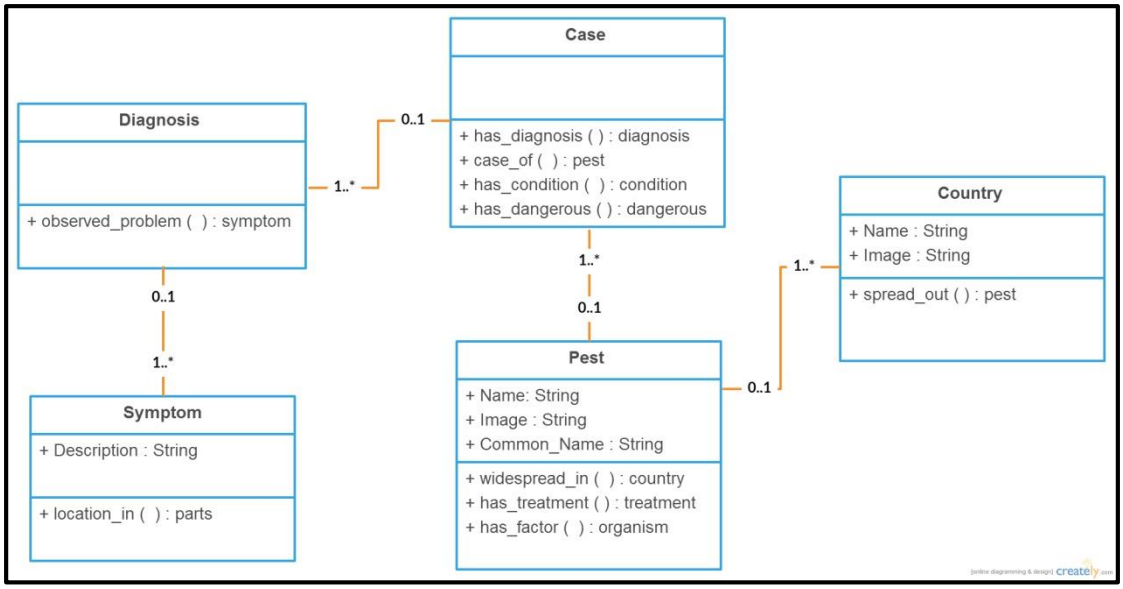

Figure 6.13: Class diagram of main classes in system

All these steps are managed by a servlet, which receives the data request. This Servlet does all of these steps sequentially as shown in this code:

```
FileManager.get().addLocatorClassLoader(Main.class.getClassLoader());
Model model = FileManager.get().loadModel("AgriDPalmOnto.owl");
Reasoner reasoner = RDFSRuleReasonerFactory.theInstance().create(null);
InfModel inf = ModelFactory.createInfModel(reasoner, model);
String parts = ("… query SPARQL …");
Query query = QueryFactory.create(parts);
QueryExecution agri = QueryExecutionFactory.create(query, inf);
ResultSetRewindable results = ResultSetFactory.makeRewindable(agri.execSelect());
```

The steps followed in the diagnosis of a date palm disease are:
Step 1: when clicking on the diagnosis of disease link.

Step 2: the system shows the two options shown in Figure 6.14 (diagnosis of the disease by Country 'تشخيص المرض من خلال الدولة' , diagnosis of the disease by the infected part 'تشخيص المرض من خلال الجزء المصاب').

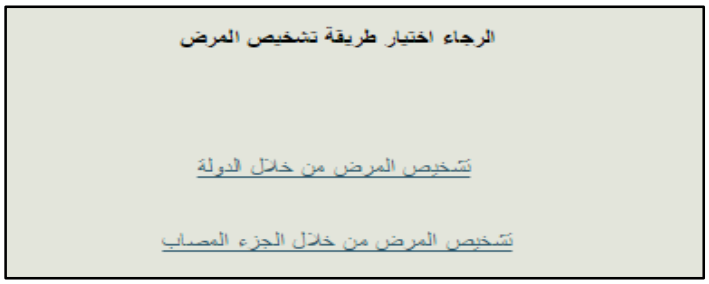

Figure 6.14: Step 2 determine the diagnosis method

Step 3: when the user selected first option, system execute SPARQL query that Shown at the bottom. This query given user to select the country in which he resides. The result show in Figure 6.15 that present name country and image.

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
        SELECT ?country ?name ?img
        WHERE {  ? country       rdf:type          AgriDPOnto:Countries.
                        ? country       AgriDPOnto:name         ?name.
                        ? country       AgriDPOnto:image        ?img.}
```

Figure 6.15: Step 3 country result query

In addition to the presence of an option for the user (see query code), to see the code which was implemented as in Figure 6.16.

Figure 6.16: Window to view the query code

Step 4: after selecting the country, the user must select symptoms based on the classification in three categories: *Appearance* 'المظهر الخارجي', *Color* 'اللون الظاهر' and *Diseases_Signs* 'العلامات المرضية' that is shown in Figure 6.17.

Figure 6.17: Step 4 symptoms problem classification

Steps 5 and 6: after selecting the type of symptoms, the system displays all symptoms of diseases belonging to this type, the user provides input by selects one or more symptoms from a list of multiple option through checkbox. The system can respond to up to five options which are sufficient to diagnose any disease. The result may be a single solution or a list of possible solutions. Figure 6.18 shows the result containing symptom, image available and location in the tree. Figure 6.19 shows user's choice of some symptoms. The query that is used shown is:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
      SELECT *
      WHERE { ?a    rdf:type    AgriDPOnto:"+typeSymptom+". ?a    rdfs:label    ?l.
              ?a    AgriDPOnto:location_in    ?lo. ?lo    rdfs:label    ?lo1.
               ?a    AgriDPOnto:image    ?img.  ?d  AgriDPOnto:observed_problem  ?a.
               ?c    AgriDPOnto:has_diagnosis  ?d. ?c  AgriDPOnto:case_of    ?p.
               ?p   AgriDPOnto:widespread_in AgriDPOnto:"+myCountry+" }
                   ORDER BY DESC(?lo1).}
```

Figure 6.18: Step 5 symptoms appear on parts of date palm

Figure 6.19: Step 6 user selected some symptoms

Step 7: Figure 6.20 shows the results of the system in response to the queries related to symptoms where it returns the appropriate diagnosis. The query used for this purpose is:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
        SELECT ?diagnosis ?labeldiagnosis
        WHERE {{ ?diagnosis     AgriDPOnto:observed_problem     AgriDPOnto:"+symptom[0]+".
                    ? diagnosis     rdfs:label    ? labeldiagnosis. }
                  union
                { ? diagnosis     AgriDPOnto:observed_problem       AgriDPOnto:"+symptom[1]+".
                    ? diagnosis      rdfs:label       ? labeldiagnosis. } }
                  ORDER BY (?labeldiagnosis)}
```

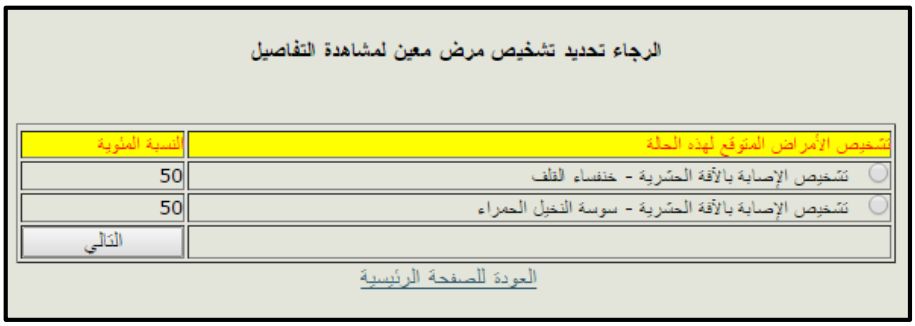

Figure 6.20: Step 7 diagnosis of disease

Step 8: when a user selects the strongest diagnosis based on the percentage through a radio box, the system shows all final symptoms of the disease that is shown in Figure 6.21. The query that is used to display all symptoms of the disease and case of disease is:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
        SELECT ?descSymptom ?labelCase ?case ?img
        WHERE {   AgriDPOnto:"+diagnosis1+"      AgriDPOnto:observed_problem      ?symptom.
                    ?symptom     AgriDPOnto:Description     ?descSymptom.
                    ?symptom     AgriDPOnto:image       ?img.
                     ?case       AgriDPOnto:has_diagnosis      AgriDPOnto:"+ diagnosis1+".
                     ?case       rdfs:label      ?labelCase.}");
```

Figure 6.21: Step 8 symptoms of disease

Step 9: when a user selects the case of disease through radio box, the system shows name of case, environmental conditions of disease, diagnosis of disease and the danger the disease represents as shown in Figure 6.22. The query that is used for this purpose is:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
        SELECT  *
       WHERE {AgriDPOnto:"+case1+"    AgriDPOnto:case_of      ?pest.
                    ?pest    rdfs:label    ?labelPest.
        OPTIONAL {AgriDPOnto:"+ case1+"   AgriDPOnto:has_condition    ?condition.
                    ?condition    AgriDPOnto:Description    ?labelCondition }.
        OPTIONAL {AgriDPOnto:"+ case1+"    AgriDPOnto:has_diagnosis    ?diagnosis.
                    ?diagnosis    rdfs:label    ?labelDiagnosis }.
       OPTIONAL {AgriDPOnto:"+ case1+"   AgriDPOnto:has_dangerous      ?dangerous.
                    ?dangerous      AgriDPOnto:Description      ?labelDangerous }}
```

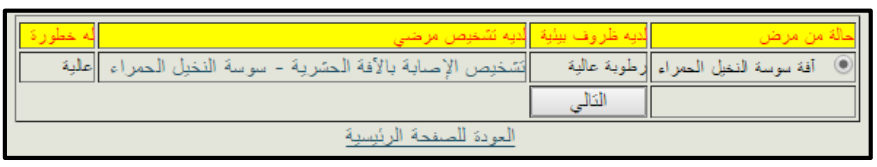

Figure 6.22: Step 9 case of disease

Step 10: when a user selects a case of disease "حالة من مرض" through radio box, the system shows name of disease, common name, pathogen scientific name and image. In

addition to the details of traditional and chemical treatment beside concentration of the pesticide shown in Figure 6.23. The query that is used for this purpose is:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
    SELECT DISTINCT *
        WHERE { AgriDPOnto:"+disease+"      AgriDPOnto:name       ?nameDisease.
        OPTIONAL {AgriDPOnto:"+ disease +"   AgriDPOnto:Common_Name    ?commnName. }
        OPTIONAL {AgriDPOnto:"+ disease +" AgriDPOnto:has_factor   ?pathogen.
                    ?pathogen       AgriDPOnto:scientific_name       ? scientificName}
       OPTIONAL {AgriDPOnto:"+ disease +"      AgriDPOnto:image       ?img}
```

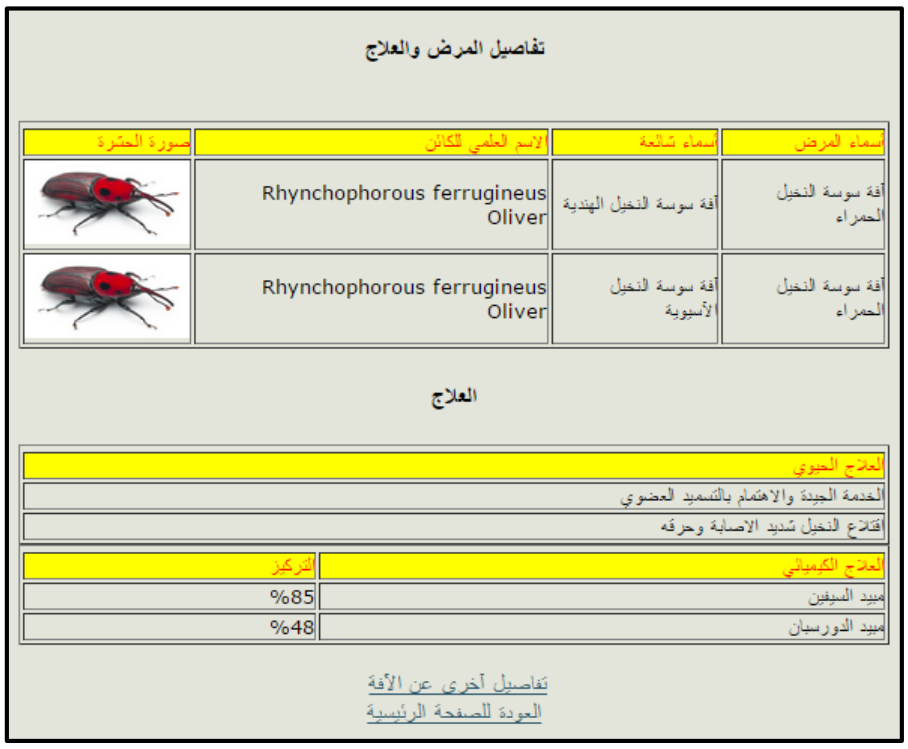

Figure 6.23: Step 10 detail disease, pathogen and treatment

Step 11: to view the details of the disease, the user can click on "Disease details" link. Figure 6.24 displays results of the disease, disease name, image and short overview about disease. The query that is used for this purpose is:

```
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX AgriDPOnto: <http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#>
    SELECT DISTINCT *
        WHERE { AgriDPOnto:"+disease+"      AgriDPOnto:image       ?img.
                AgriDPOnto:"+ disease +"    AgriDPOnto:name        ? diseaseName.
                AgriDPOnto:"+ disease +"      rdfs:comment           ?comment. }
                ORDER BY DESC(?diseaseName)
```

Figure 6.24: Step 11 detail disease or pest

Step 12: the previous queries can be performed to diagnose the disease in a different way through infected part tree as shown in Figure 6.14 (Step 2). When a user selects the second option, the system shows the parts of the tree shown in Figure 6.25. Where the system automatically classifies symptoms by selected part tree.

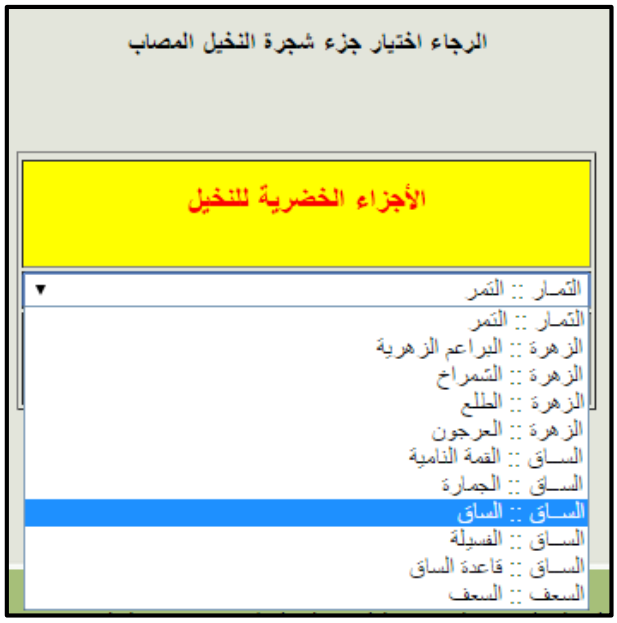

Figure 6.25: Parts of date palm tree

6.5 Viewing Date Palm Diseases

The user can view the available palm diseases in the knowledge base through clicking on the palm diseases "أمراض النخيل" option in the main web page. Where the list appears containing pests and diseases that infect the date palm tree. Figure 6.26 shows a list of pests and diseases affecting the date palm tree. Figure 6.27 shows a list of type pests that available in insect pests "آفات حشرية".

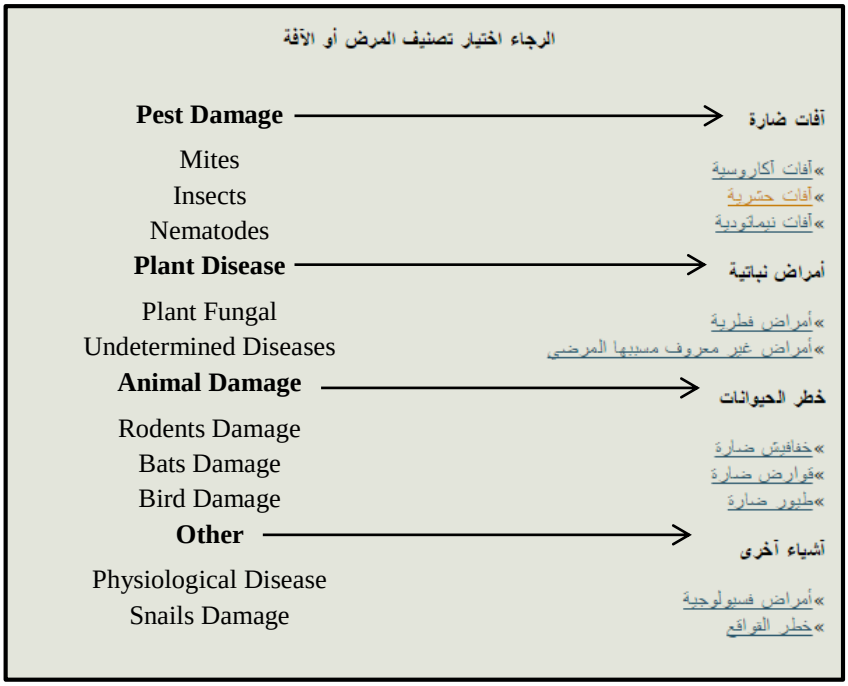

Figure 6.26: Classification of diseases and pests

Figure 6.27: Types of insect pests in date palm

6.6 View AgriDPalmOnto Knowledge Base Hierarchy

View *AgriDPalmOnto* knowledge base hierarchy by browsing and displaying contents *AgriDPalmOnto* knowledge base. The agricultural engineer clicks the

"AgriDPalmOnto" menu item, the web operation is invoked to return the *AgriDPalmOnto* knowledge base in OWL file. This file is traversed and displayed in a hierarchical view as shown in Figure 6.28. This hierarchical view allows the user to browse the country, diseases, pests, symptoms, signs, and treatment classes of the *AgriDPalmOnto* knowledge base.

Figure 6.28: Hierarchical view of AgriDPalmOnto

6.7 Summary

In this chapter, we have presented the phases of implementing the *AgriDPalmOnto* system according to the design of *AgriDPalmOnto* components that are designed in system design phase. We focused on the Web application system, as well as some of the queries that have been used in the semantic search, diagnosis of disease, view date palm diseases and view the hierarchy of the system.

Chapter 7
Experimental Results and Evaluation

In this chapter, we present the experiments performed for the evaluation of the proposed *AgriDPalmOnto* ontology and *AgriDPalmOnto* system. The ontology evaluation is performed using precision, recall, and accuracy. Additionally, we evaluate the ontology through the well-known Task-Based framework. The system evaluation is performed through answering diagnoses, symptoms, and treatment questions compared to a reference documented scientific answers as well as the answers of an agricultural expert in the field of date palm.

7.1 AgriDPalmOnto Ontology Evaluation of Coverage

This section presents the evaluation of *AgriDPalmOnto* ontology using the precision, recall [62] and Task-Based framework that is illustrated in Section 3.3.2.2 (Ontology Evaluation). We depend on the Golden standard and the help of a domain expert in the field of date palm. Correct concepts are decided based on the Golden standard which could be another ontology or prepared by domain experts [Appendix C].

Precision is number of correct concepts in the ontology relative to the total number of concepts in the ontology as shown in equation 7.1 and Recall is number of correct concepts in the ontology relative to total number of possible concepts as shown in equation 7.2.

$$\text{Precision} = \frac{\text{Number of correct concepts in the ontology}}{\text{Total number of concepts in the ontology}} \quad \text{.. eq (7.1)}$$

$$\text{Recall} = \frac{\text{Number of correct concepts in the ontology}}{\text{Total number of possible concepts}} \quad \text{.. eq (7.2)}$$

In general precision is a metric that is used to indicate how accurately the concepts identified in the ontology represent the domain. Recall is used to measure the coverage of the ontology.

In our case we relied on the domain expert to evaluate the ontology by asking him about the shortage in the ontology concepts/classes. He identified 50 correct classes and the total number of classes is 53 then the Precision would be:

Precision = 50/53= 94.3%

Also in our case the domain expert said there is still missing 2 concept/class that the ontology does not cover. Then the total number of possible concepts equal 55 and the Recall would be:

Recall = 50/55= 90.9%

The same way we can calculate the instances or individuals of the ontology by asking the domain expert about the shortage in ontology instances the domain expert identified 496 correct instances and the total number of instances is 503, therefore the Precision would be:

Precision= 496/503= 98.6%

Also in our case the domain expert said there is still missing 12 instances or individuals that the ontology does not cover. Then the total number of possible instances equal 515 and the Recall is:

Recall= 503/515= 97.7%

Table 7.1 summarizes the Precision and Recall ontology evaluation for classes and instances (individuals).

Table 7.1: Precision and Recall ontology evaluation

Metric	Classes	Instances (Individuals)
Precision	94.3%	98.6%
Recall	90.9%	97.7%

The elements of Task-Based are Task, Ontology, Application, and Gold Standard. In this evaluation, disease diagnose represents the Task element, *AgriDPalmOnto* ontology represents the Ontology element, *AgriDPalmOnto* system represents the Application, and the specialist of date palm diseases represents the Gold Standard.

For evaluating the performance of the *AgriDPalmOnto* approach, we have employed the semantic relation error types of the Task-Based framework as follows:

- **Deletions:** missing relations in places a relation ought to be identified. An example of deletion in this task is delete the has_diagnosis 'له تشخيص' relation between the Case_of_disease 'حالة مرضية' and Diagnosis_of_disease ' تشخيص المرض', when we delete this relation the system could not identify the diagnosis of disease.
- **Insertions:** postulating any relation to hold where none ought to been. An example of insertion in this task is insert new (Especial_Disease 'مرض نادر') relation between the symptoms and disease, when we insert this relation the diagnosis of disease will not be accurate.
- **Substitutions:** postulating a specific relation to hold where some other ought to been. For example if we substitute any relation with other relation, diagnosis of disease will not be accurate.

As compared to the Gold Standard, we obtained the accuracies, deletions, insertions, and substitutions as shown in Table 7.2.

Table 7.2: Results overview

Overall Accuracy	**96.7**
Deletions	0%
Insertions	0%
Substitutions	0%

These results provide a comparable measure for evaluating the performance of the *AgriDPalmOnto* system on this nontrivial task. They clearly indicate that the accuracy is 100% in the used *AgriDPalmOnto* knowledge base. The 0% deletions indicate clear cases where a pertinent relation modeled in the ontology, the 0% of the insertions could be regard as superfluously model relations, and the 0% of the substitution errors showed efficiencies in the model.

7.2 AgriDPalmOnto System Evaluation of Coverage [Appendix C]

This section explains how the experimental test is applied to evaluate the accuracy of the *AgriDPalmOnto* system according to an agricultural expert in the field of date palm. We have a manual testing through a questionnaire composed of a group processing questions will be presented to an expert in the field, and then the same questions will be resolved on the proposed system and then compare the results.

Testing included 20 questions about the diagnosis of disease, identify disease through the symptoms and determine the appropriate treatment. Questions sample selection criteria were based on comprehensiveness in ontology concepts, which is to diagnose the disease through symptoms, questions included the following:

- Show symptoms of the disease specific
- Show chemotherapy for a particular disease
- Show traditional treatment for particular disease
- Show the name of the disease through common name for this disease
- Determine the seriousness of the disease
- Show associated with the disease environmental conditions
- Show the names of certain diseases and hierarchical information
- Show the concentration of a particular pesticide

Questions were collected from reliable and scientific references, it has been selected the state of Palestine as an experiment to test. The test described in a supplement and the questions were as shown in Table 7.3.

Table 7.3: Question Arabic and English experimental evaluation

Question in English	Question in Arabic	
What is the pathological diagnosis of the following symptoms؟ 1. Appearance of a reddish-brown thick sticky secretion with heavy dour and the liquid oozes with large amount on the infected trunk from the outside.	ما هو التشخيص المرضي للأعراض التالية: 1-ظهور افراز سـميك القوام لزج لونـه بنى محمر ذو رائحة نفاذة ويسـيل الافراز بكمية كبيرة على الجذع المصاب من الخارج. 2-اصـفرار السـعف الموجود في قلب النخلة وتهدله.	1

2. The leaf at the bottom of the palm gets yellow and weak.		
What is the pathological diagnosis of the following symptoms؟ 1. It is noticed that noticeable pustules on the old leaves have a diameter of up to about 0.2 mm and a height of 0.5 mm and surrounded by external coating. **2.** When the infected leaf is shacked, the mash room spores spread on the shape of yellow dust.	ما هو التشخيص المرضي للأعراض التالية: 1-يلاحظ بثرات بارزة على الأوراق القديمة قد يصل قطرها إلى حوالي 2 مم وارتفاعها 0.5 مم ومحاطة بغلاف خارجي. 2-عند اهتزاز السعفة المصابة تتناثر جراثيم الفطر على هيئة غبار أصفر.	2
What is the pathological diagnosis of the following symptoms؟ 1. It is noticed that the palm's top is getting rot and black. The tissues gets charred and palms is dead. **2.** It is noticed that rooting flowers and flower racemes in pollen.	ما هو التشخيص المرضي للأعراض التالية: 1- يلاحظ تعفن قمة النخلة واسوداده وتفحم أنسجته وموت النخلة. 2- يلاحظ تعفن الأزهار والشماريخ الزهرية داخل الطلع.	3
What is the pathological diagnosis of the following symptoms؟ 1. Its witnessed that the bug feed on the blossom of the palm pollen, so the raceme is empty. **2.** The blossom and flower raceme is decayed inside the pollen.	ما هو التشخيص المرضي للأعراض التالية: 1-يشاهد تغذي الحشرة على الأزهار في الطلع وخلو الشمراخ من الثمار. 2-تعفن الأزهار والشماريخ الزهرية داخل الطلع.	4
What is the pathological diagnosis of the following symptoms? 1. The bugs gathered around the infected part. Noticing that they have white or reddish-pink color covered with white waxy coat. 2. There is a tissue with sticky sand covering the dates which makes the dates touch hand. When pressing on them, they are corky.	ما هو التشخيص المرضي للأعراض التالية: 1-ملاحظة تجمع الحشرة بلون أبيض أو أحمر قرنفلي على الجزء المصاب مغطى بطبقة شمعية بيضاء. 2-وجود نسيج يغطى الثمار والعذوق تلتصق به ذرات التراب ويكون ملمس الثمار خشنا وعند الضغط عليه يكون فليني	5
What are the symptoms of Red palm weevil disease?	ما هي أعراض مرض سوسة النخيل الحمراء ؟	6
What are the symptoms of Bayoud disease?	ما هي أعراض مرض البيوض ؟	7
What are the symptoms of Bast pest?	ما هي أعراض مرض آفة اللحاء ؟	8
What is the proper chemotherapy to White Termite ?	ما هو العلاج الكيميائي المناسب لمرض آفة النمل الأبيض؟	9
What is the proper chemotherapy to date palm Dubas bug?	ما هو العلاج الكيميائي المناسب لمرض آفة دوباس النخيل ؟	10
What is the proper biological or traditional to Red palm weevil disease?	ما هو العلاج الحيوي المناسب لمرض سوسة النخيل الحمراء ؟	11
What is the proper biological Alujam disease?	ما هو العلاج الحيوي المناسب لمرض الوجام؟	12
What are the common name for Borer pest ?	من الأسماء الشائعة لآفة الحفار ؟	13
What are the common name for Red palm weevil pest ?	من الأسماء الشائعة لآفة سوسة النخيل الحمراء ؟	14
What are the danger of decaying the Inflorescence rot ?	ما هي خطورة مرض عفن طلع النخيل ؟	15
What are the danger of decaying the Diplodia leaf base rot ?	ما هي خطورة مرض الدبلوديا ؟	16
What are the suitable environment circumstance for Black scorch ?	ما هي الظروف البيئية الملائمة لمرض اللفحة السوداء ؟	17
What are the suitable environment circumstance for Nitrogen deficiency ?	ما هي الظروف البيئية الملائمة لمرض الاصفرار الناتج عن نقص النيتروجين ؟	18

What are the disease which have unknown causes?	مـا هي الأمراض الـغير معروف مســببهـا المرضي؟	19
The concentration used with Dursban pesticide ?	التركيز المستخدم مع مبيد الدورسبان ؟	20

After this detail about questions, we will present and clarify the results obtained after testing the *AgriDPalmOnto* system according to expert user as shown in Table 7.5.

Table 7.4 shows the scientific answer of the questions shown in Table 7.3 according to scientific books and references agreed like a book palm diseases in the Arab World.

Table 7.4: Scientific answer of question Arabic and English

Scientific answer of question English	Scientific answer of question Arabic	Number of Question
The incidence of insect pest - red palm weevil	الإصابة بالآفة الحشرية - سوسة النخيل الحمراء	1
The incidence of disease - graphiola leaf spot	الإصابة بمرض تبقع الأوراق الجرافيولي	2
First: Black scorch Second: Inflorescence rot	العرض الأول: الإصابة بمرض اللفحة السوداء العرض الثاني: الإصابة بمرض عفن الطلع	3
First: Greater date moth Second: Inflorescence rot	العرض الأول: الإصابة بالآفة الحشرية – دودة البلح الكبرى العرض الثاني: الإصابة بمرض عفن الطلع	4
First: Mealy Bugs Second: Old world date mite	العرض الأول: الإصابة بالآفة الحشرية – بق النخيل الدقيقي العرض الثاني: الإصابة بالآفة الأكاروسية – حلم الغبار	5
- Appearance of a reddish-brown thick sticky secretion with heavy dour and the liquid oozes with large amount on the infected trunk from the outside. - The emergence of rotting wooden sawdust as a result of feeding infected larvae out of the trunk of the palm. - The death of the existing Offshoot area of injury. - The leaf at the bottom of the palm gets yellow and weak.	- ظهور افراز سميك القوام لزج لونه بنى محمر ذو رائحة نفاذة. - ظهور نشارة خشبية متعفنة نتيجة تغذية اليرقات خارج جذع النخلة المصابة. - موت الفسيلة أو الراكوب الموجود منطقة الإصابة . - اصفرار السعف الموجود قلب النخلة وتهدله.	6
- Palm leaf starts curving and takes a distinctive form where wicker sticks on it so it looks like a wet chicken feather hanging down toward the trunk. - The infected palm leaf with gray-brown color started shriveling until some wicker or thorns on one side became white. - Light brown lines appear and its color gets darken along the bottom surface of the leaf, which is called the dorsal surface. - A general yellowing of the leaf is noticed before the appearance of the symptoms.	- تتقوس السعفة وتأخذ شكلاً مميزاً حيث يلتصق الخوص عليها فتشبه بذلك ريشة الدجاج المبللة بالماء وتتدلى إلى أسفل باتجاه جذع النخلة. - تظهر السعفة المصابة باللون الرمادي البني ثم تذبل حتى يصبح بعض الخوص أو الأشواك من جهة باللون الأبيض. - تظهر خطوط بنية فاتحة يغمق لونها على امتداد السطح السفلي للجريد والذي يسمى بالسطح الظهري. - يلاحظ اصفرار عام بالسعف قبل ظهور الأعراض المميزة للمرض.	7

- When making a transverse sector on the roots or the trunk or the leaf. It is noticed that vascular bundles and tissues became brown-ruddy color.	- عند عمل قطاع عرضي بالجذور او بالجذع او السعفة يلاحظ تلون الحزم الوعائية والانسجة بها بلون بني ضارب للحمرة.	
- The presence of small holes scattered sawdust, wood soft appear as a result of digging insects - The weakness of the tree trunk and easily break	- وجود ثقوب صغيرة مبعثرة تظهر منها نشارة خشبية ناعمة نتيجة حفر الحشرات - ضعف الشجرة وسهولة كسر الجذع	8
Dursban or Alhoutathion or Alsomsudain	- مبيد الدورسبان أو مبيد الهوتاثيون أو مبيد السومسدين	9
Malathion or Oktelic	- مبيد الملاثيون أو مبيد أكتليك	10
- Good service and attention to organic fertilization - Uprooting palm severe injury and burn it and get rid of it - Get rid of weeds and turning the soil.	- الخدمة الجيدة والاهتمام بالتسميد العضوي - اقتلاع النخيل شديد الإصابة وحرقه والتخلص منه - التخلص من الحشائش وتقليب التربة.	11
- Good service and attention to organic fertilization - Moderation in irrigation and increase the distance between the soil to reduce humidity. - Need to adhere to the laws of the international agricultural booking firmly.	- الخدمة الجيدة والاهتمام بالتسميد العضوي - الاعتدال في الري وزيادة المسافات بين التربة لتقليل الرطوبة. - ضرورة الالتزام بقوانين الحجز الزراعي الدولي بكل حزم.	12
The mole cricket	- كلب البحر	13
- Indian palm weevil - Asian palm weevil	- سوسة النخيل الهندية - سوسة النخيل الآسيوية	14
High risk	- خطورة عالية	15
Medium risk	- خطورة متوسطة	16
- The disease is available at: Cool temperature or high humidity	- يتوفر المرض في : درجة حرارة معتدلة أو رطوبة عالية	17
Is not related to environmental conditions is a physiological disease	- غير متعلق بالظروف البيئية فهو مرض فسيولوجي	18
- Yellowing of the lanner leaves - Bending head of date palm - Rapid decline or rhizozis - PuLethal yellowing - Dry bone - Wajam	- مرض اصفرار السعف الداخلي - مرض انحناء الرأس في النخيل - مرض التدهور السريع - مرض الاصفرار القاتل - مرض العظم الجاف - مرض الوجام	19
Concentration: 48%	التركيز المستخدم هو : 48%	20

Table 7.5 shows a comparison between the answer proposed system and the answer agricultural expert. As well as the percentage of answer accuracy for scientific answer.

Table 7.5: Answer system and answer agricultural expert

%	Answer agricultural expert	%	Answer system	No. of Question
%50	- سوسة النخيل الحمراء - البيوض الكاذب	%100	تشخيص الإصابة بالآفة الحشرية - سوسة النخيل الحمراء بنسبة 100%	1
%100	- التفحم الكاذب "الجرافيولي"	%100	تشخيص الإصابة بمرضى- تبقع الأوراق الجرافيولي بنسبة 100%	2

3	تشخيص الإصابة بمرض - اللفحة السوداء بنسبة 50% تشخيص الإصابة بمرض - عفن الطلع بنسبة 50%	%100	- تعفن القلب " اللفحة السوداء" أو المجنونة - عفن طلع النخيل "الخماش"	%100
4	تشخيص الإصابة بالآفة الحشرية - دودة البلح الكبرى بنسبة 50% تشخيص الإصابة بمرض - عفن الطلع بنسبة 50%	%100	- دودة البلح الصغرى "الحميرة" - عفن طلع النخيل "الخماش"	%50
5	تشخيص الإصابة بالآفة الحشرية - بق النخيل الدقيقي بنسبة 50% تشخيص الإصابة بالآفة الأكروسية - حلم الغبار بنسبة 50%	%100	- البق الدقيقي "أنواع مختلفة" - حلم الغبار	%100
6	• موت قلب النخلة – الجمارة • انكسار جذع النخلة من عند الثلث القاعدي وملاحظة تجوفه ووجود أطوار الحشرة بداخله • ظهور نشارة خشبية متعفنة هي نواتج التغذية لليرقات خارج جذع النخلة المصابة ، قد تشاهد النشارة على الأرض • موت الفسيلة أو الراكوب الموجود منطقة الاصابة • اصفرار السعف الموجود في قلب النخلة وتهدله • عند استخدام آلة حادة في الجذع تظهر فراغ وتجويف • ظهور إفراز سميك القوام لزج لونه بنى محمر ذو رائحة نفاذة ، ويسيل الإفراز بكمية كبيرة على الجذع المصاب من الخارج	%100	• تهتك الخلايا الداخلية وتعفنها • جفاف الأوراق • وجود مادة شمعية بنية لها رائحة كريهة • الإصابة الشديدة تؤدى لانكسار الجذع النخلة لعوامل ميكانيكية	%60
7	• عند عمل قطاع عرضي يلاحظ تلون الحزم الوعائية والأنسجة البرنشيمية المحيطة بها بلون بنى محمر • تظهر خطوط بنية فاتحة يغمق لونها على امتداد السطح السفلي للجريد والذي يسمى بالسطح الظهري • تظهر السعفة المصابة باللون الرمادي البني ثم تذبل حتى يصبح بعض الخوص أو الأشواك من جهة باللون الأبيض	%100	• يظهر على أحد جانبي بعض السعف اصفرار من قاعدة الورقة إلى أعلى إلى أن تصبح صفراء كلها، ثم يهبط من الجانب الآخر إلى أن تصبح الورقة صفراء تماما.	%50
8	آفة الحشرة القشرية المدرعة ، وعند البحث عن أعراض هذه الآفة لم ترجع نتائج لوجود خطأ معين.	%50	- لم يتم التعرف على الاسم الشائع للآفة	%0
9	• مبيد الهوستاثيون أو • مبيد السيديال أو • مبيد الدورسبان أو • مبيد السوميسدين	%100	كونفيدور "تجريع في التربة" (يستخدم في فلسطين ولكن غير فعال)	%0
10	• مبيد الملاثيون	%50	كونفيدور " تجريع 5سم للشجرة" (يستخدم في فلسطين ولكن غير فعال)	%0
11	الخدمة الجيدة والاهتمام بالتسميد العضوي	%70	تطبيق الحجر الزراعي	%30

	اقتلاع النخيل شديد الاصابة وحرقه		(تعريف شامل يندرج من خلاله اقتلاع النخيل المصاب وحرقه والتخلص منه)	
12	-	%0	- خدمة بستانية جيدة - تعقيم الأرض - عدم نقل الأشجار الموبوءة - حرق الأشجار المصابة	%100
13	كلب البحر	%100	السوسة	%0
14	آفة سوسة النخيل الهندية آفة سوسة النخيل الآسيوية	%100	الصرصور (اسم شائع محلي بين المزارعين وغير موثق)	%20
15	عالية	%100	عالية	%100
16	متوسطة	%100	متوسطة	%100
17	حرارة معتدلة رطوبة عالية	%100	وصول ماء الري لقلب الفسيلة	%50
18	غير متوفر لها ظروف بيئية	%100	انخفاض PH عن 6 أو أعلى من 9 (بدون توفر ظروف جوية)	%100
19	مرض إصفرار السعف الداخلي مرض الوجام مرض التدهور السريع مرض الاصفرار القاتل مرض العظم الجاف مرض إنحناء الرأس في النخيل	%100	- انحناء الرأس	%20
20	-	%0	1.5سم/لتر – 2سم/لتر (مقياس آخر عملي غير النسبة المئوية العلمية)	%100

The system was able to answer 15 questions correctly, and it answered question 8, 10 and 11 relatively, and could not answer 2 questions which 12 and 20. Thus the accuracy of the system answer is 83.5%**.**

The way used in answering questions through the system can be summarized as follows:

- Questions 1 to 4 have been answered through the diagnosis of the disease, while the 5th question has been answered by looking for symptoms in the knowledge base. The first five questions included symptoms related to color, appearance and pest.
- Questions 6 to 12 has been answered through the use of semantic search with uses of words that reflect the search process. For example, to look for the symptoms of *palm weevil disease* "آفة سوسة النخيل", write the first word in the search which is (symptoms) "أعراض" and then complete the name of the disease, as well as when searching for the treatment of disease. Knowing that questions 8 and 12 did not return results because of software errors.
- Question 13 and 14 have used direct search for name of pests and then the system shows detailed information containing the common name.
- Questions 15 to 18 have been answered through semantic search on cases of the disease, which contain the risk of the disease and environmental conditions.
- Question 19 has been answered through (palm diseases) "أمراض النخيل" option which reviews all available diseases in the knowledge base.

- Question 20 has been answered through a search option, but when the system return the pesticide data, the system does not return results in this case. The pesticide data appear in the (case of disease) "حالة المرض".

The agricultural expert was able to answer 8 questions correctly, 8 questions partially correctly, and could not answer 4 questions. The accuracy of the answers of the expert is 56.5% only**.** Thus, the proposed system has achieved an advantage over the manual system. Additionally, it was noted that the time it takes to answer questions through the proposed system is shorter than the time it takes to answer questions through the human expert.

7.3 Discussion

Through the presented evaluation, the importance of the proposed system in the diagnosis of diseases of date palm is clear, where the system has achieved an acceptable accuracy and speed compared to traditional diagnosis. But the system was limited to selecting the symptoms in the diagnosis of the disease process and lacked method of diagnosis by asking a user's system, but the system marked by showing images with symptoms which enhanced user options. What distinguishes the proposed system is its ability to diagnose diseases according to the affected part of the date palm tree. It also facilitates the diagnosis of diseases according multiple symptoms for multiple diseases and can identify pests through common name which is lacked in the agricultural expert.

7.4 Summary

In this chapter, we have evaluated the system and have discussed the results. The evaluation is divided into two phases:

In the first phase, we evaluated the ontology using the precision and recall, the accuracy is 96.7%. Then we evaluated the ontology using Task-Based framework which employs the semantic relation error types: deletions, insertions, and substitutions to validate the ontology. Then the results are compared with the Gold Standard; if the accuracy of these semantic relation errors still 0% then it indicate that the accuracy of using the *AgriDPalmOnto* ontology is 100%.

In the second phase, we evaluated the accuracy of the *AgriDPalmOnto* system according to an agricultural expert in the field of date palm. We have a manual testing with including 20 questions about the diagnosis of diseases, identifying diseases through the symptoms and determining the appropriate treatment. The system was able to answer 15 questions correctly that the accuracy is 83.5% but the agricultural expert able to answer 8 questions correctly that the accuracy is 56.5%. These results prove that the ontology supports the process of diagnosis of diseases.

Chapter 8
Conclusions and Future Work

In this research, we have developed an ontology-based approach for diagnosing date palm diseases. We first presented an overview of current traditional diagnosis, and showed that their primary shortcomings are presented in the fact that they do not diagnose diseases effectively.

We have focused on the process of building date palm diseases knowledge base. The knowledge base including the *AgriDPalmOnto* ontology and the individuals. The ontology content is related to agriculture domain and is collected from a number of relevant research papers and books related to date palm diseases and diagnosis of such diseases in Arab world. The ontology is to provide a knowledge base of diseases, pests, pathogens and symptoms. It has been used in the *AgriDPalmOnto* system to make diagnoses of the diseases of date palm and determine the cases of these diseases and to show how much effective the final results of queries are by adding knowledge to such systems in terms of ontology.

The ontology and knowledge base play important role to provide intelligent view over information resources. Therefore, ontology for diagnosis of date palm diseases, as the one generated by this study, may be a very useful resource for processing diagnosis of diseases agricultural knowledge base.

Based on the *AgriDPalmOnto* knowledge base, the *AgriDPalmOnto* system consists of several components which are Diagnosis module, Pathogenesis module, Treatment module and the Querying module. The system is implemented to consist of three inter-related parts: knowledge base, reasoning engine and server side application.

The *AgriDPalmOnto* ontology was evaluated and its accuracy reached 96.7%. Then the Task-Based framework is used to evaluate the ontology and indicated that the accuracy approached 100%.

Experiments were performed to test the system for functions such that date palm for disease diagnosis. The questions that have been tested depend on the data in ontology domain. In the evaluation process, the results that generated from the system show that the system can correctly answer 15 out of the 20 questions that the accuracy 83.5% and better than the expert in the field where the agricultural expert able to answer 8 questions correctly that the accuracy is 56.5%.

The main contribution of this research is that the ontology and the related knowledge base can support the process of date palm disease diagnoses with higher rate of accuracy and user satisfaction than traditional diagnosis.

Since only a prototype of the proposed system is implemented, it is recommended to implement a complete system. Success of our proposed prototype encourages us to

look for ways to increase the scope of this research to answer more types of questions such as comparative and similarity phrases. In addition, the ontology can be extended by adding more data and semantic information.

The querying interface need further development through the diagnosis of the disease across question user and tagged deriving and retrieve information better.

There is a need to development a web service for date palm diseases diagnosis and publish the *AgriDPalmOnto* ontology as Linked Open Data so it can be widely known and used.

Adapting the system in the agriculture field need further experimentation and field operation. This also needs communication with those in charge of the Arab Conference for Palm Pests in the project and provide a collaboration framework.

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Appendix A: Details about AgriDPalmOnto ontology

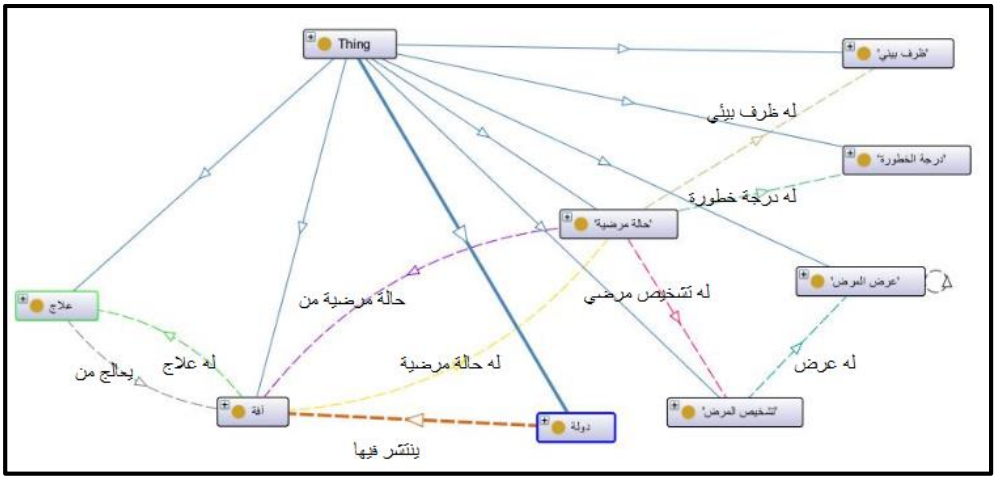

Figure A-1: The relation of proprieties between main classes.

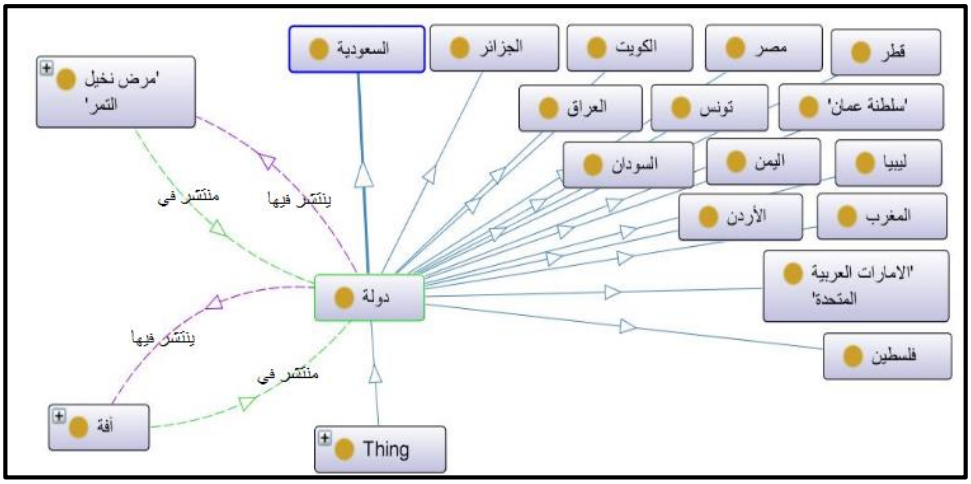

Figure A-2: Details of country class

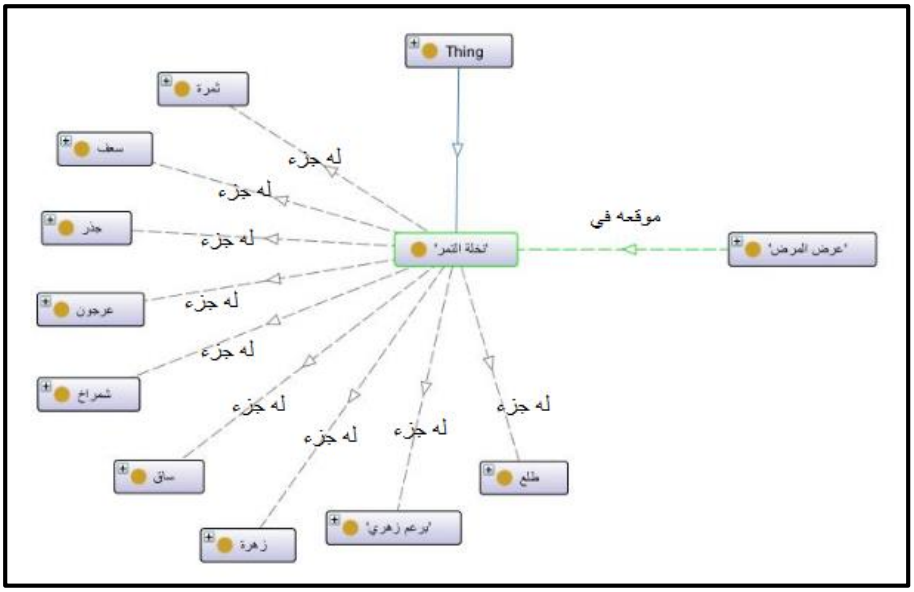

Figure A-3: Details of date palm class

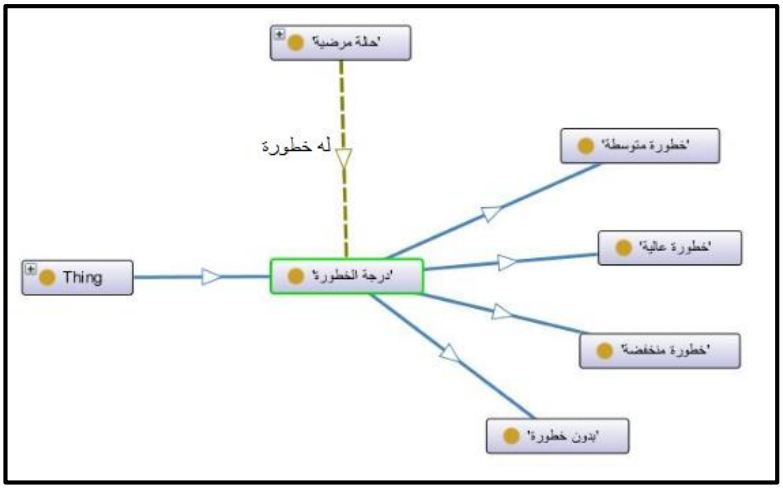

Figure A-4: Details of degree of danger class

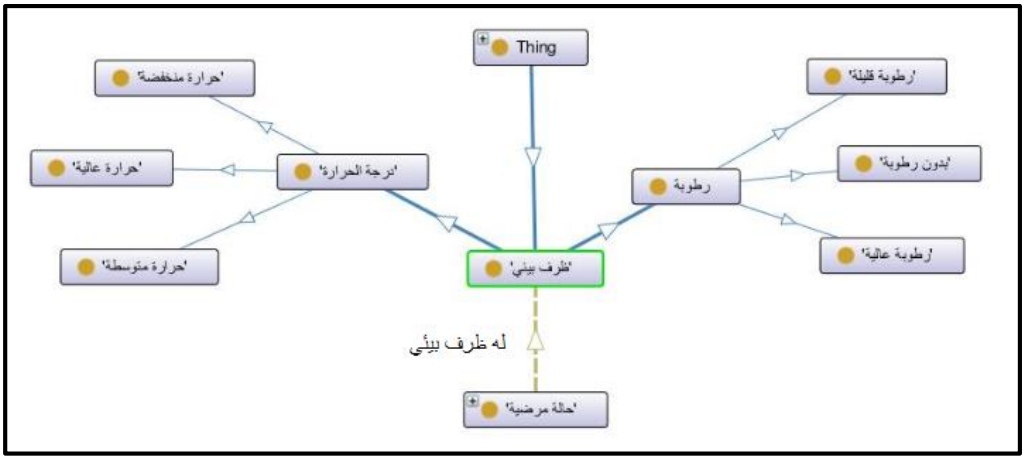

Figure A-5: Details of environment condition class

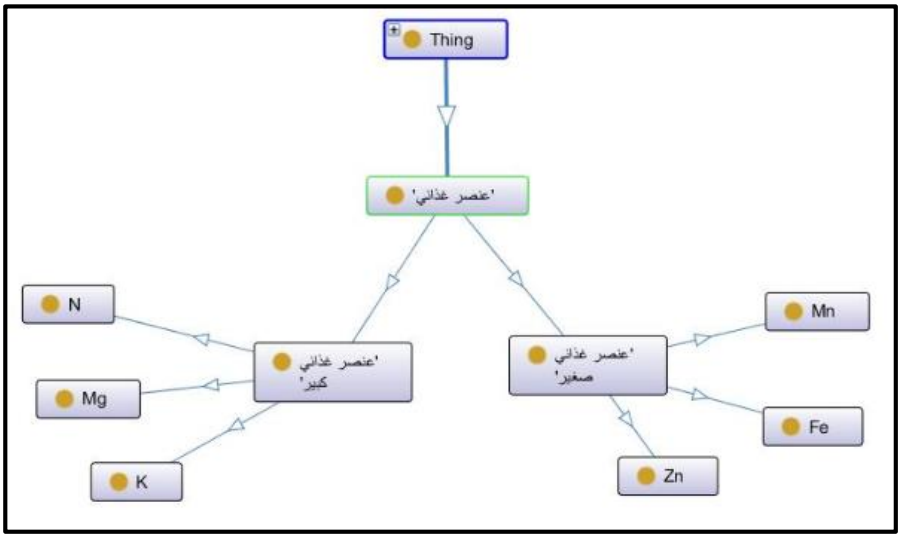

Figure A-6: Details of nutrient class

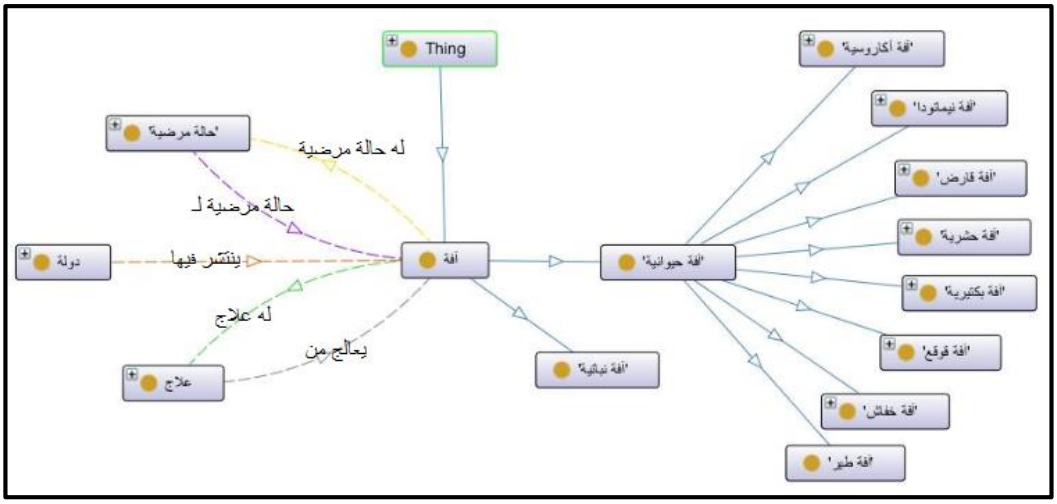

Figure A-7: Details of pest class

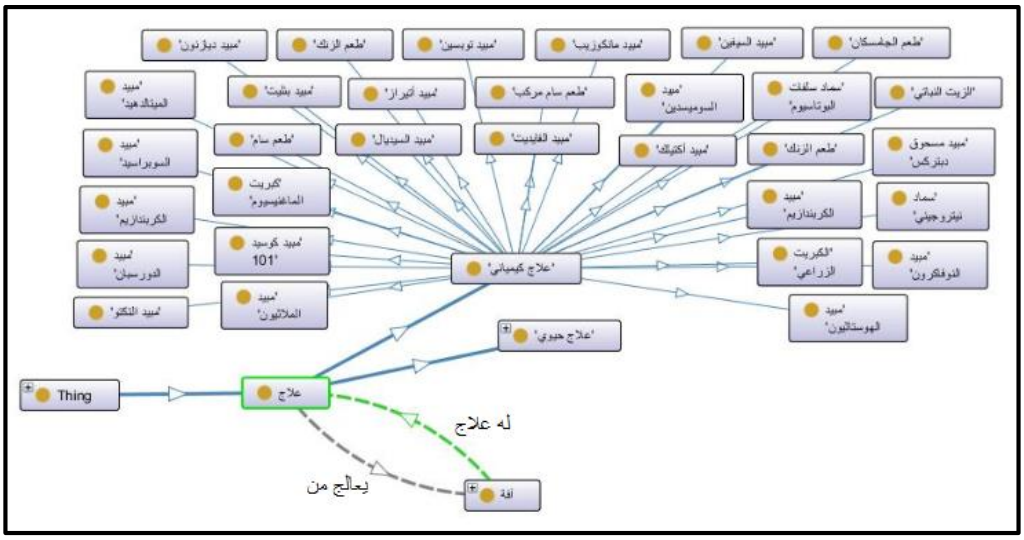

Figure A-8: Details of chemical treatment class

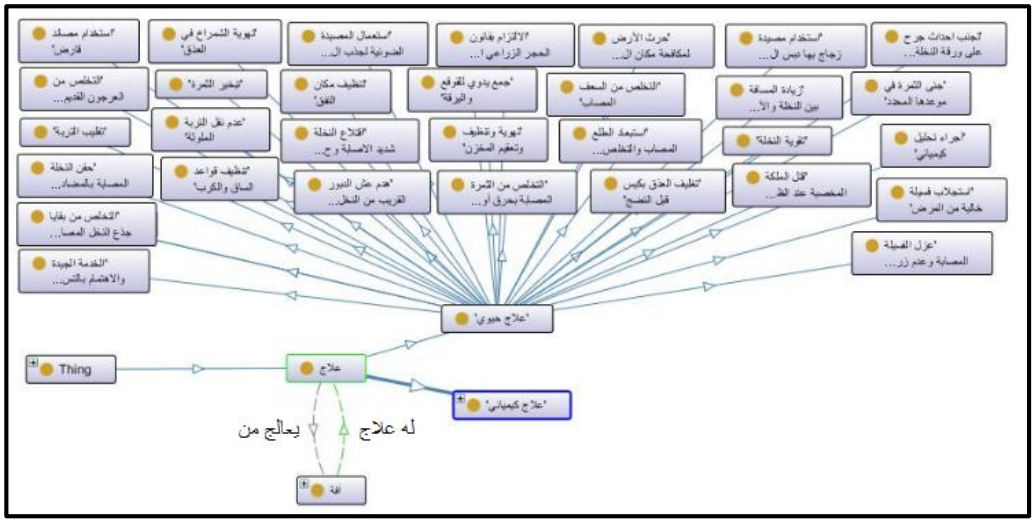

Figure A-9: Details of vital treatment class

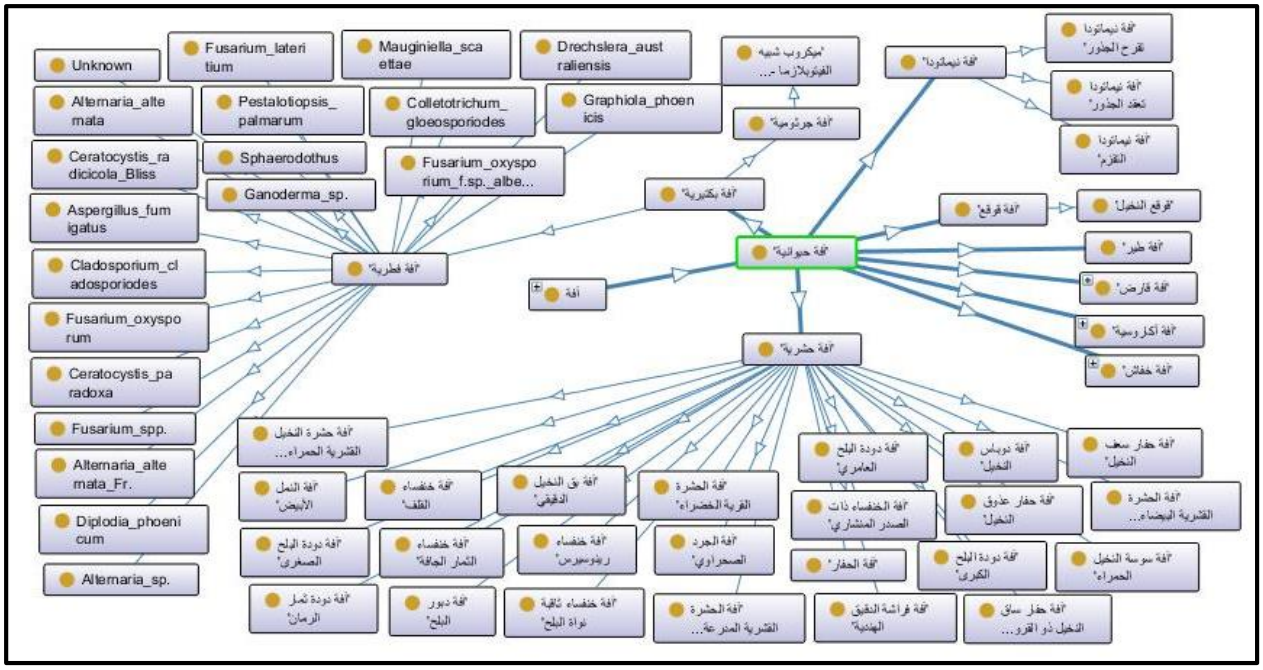

Figure A-10: Details of animal pest class

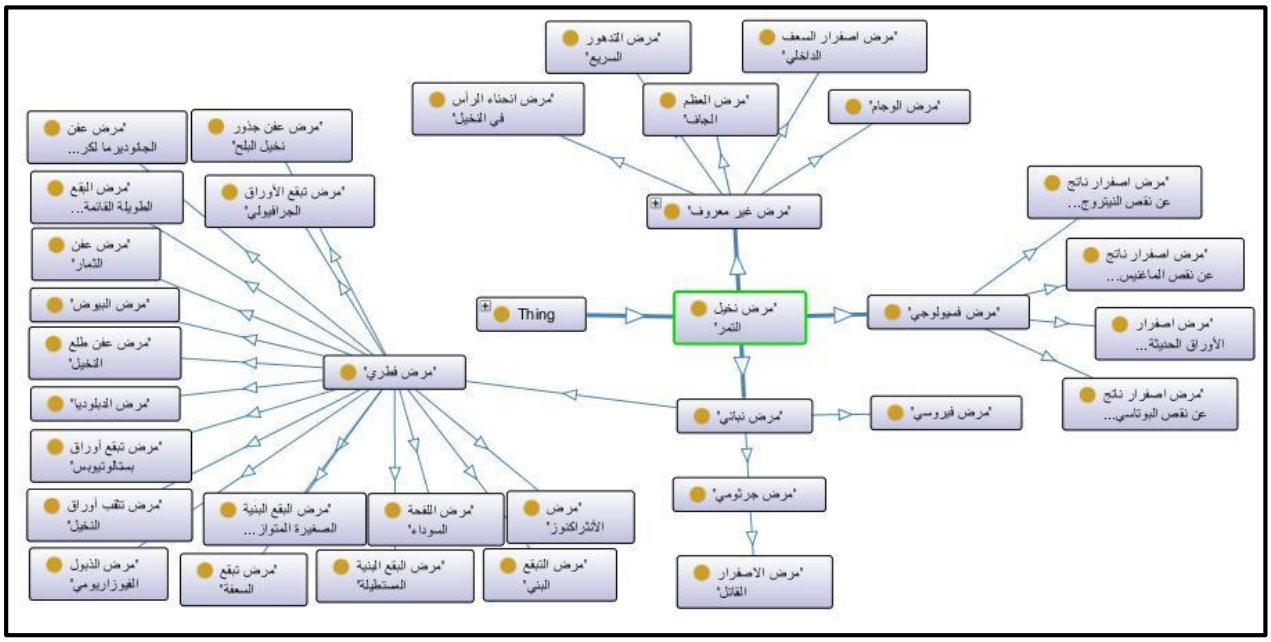

Figure A-11: Details of disease date palm class

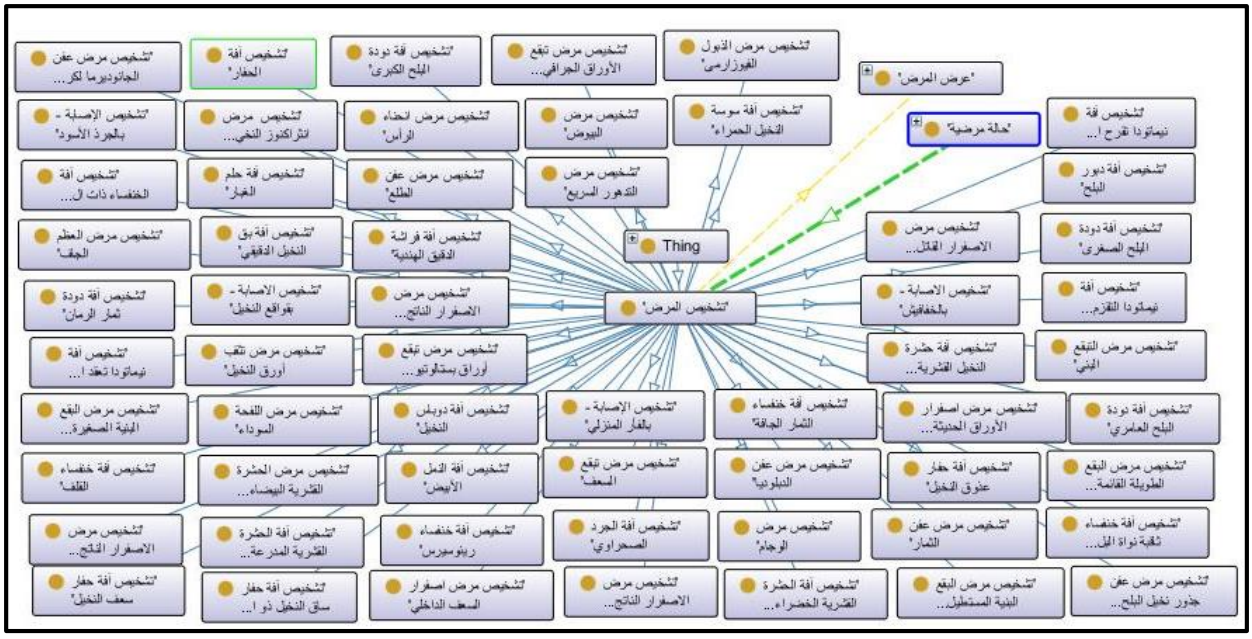

Figure A-12: Details of disease diagnosis class

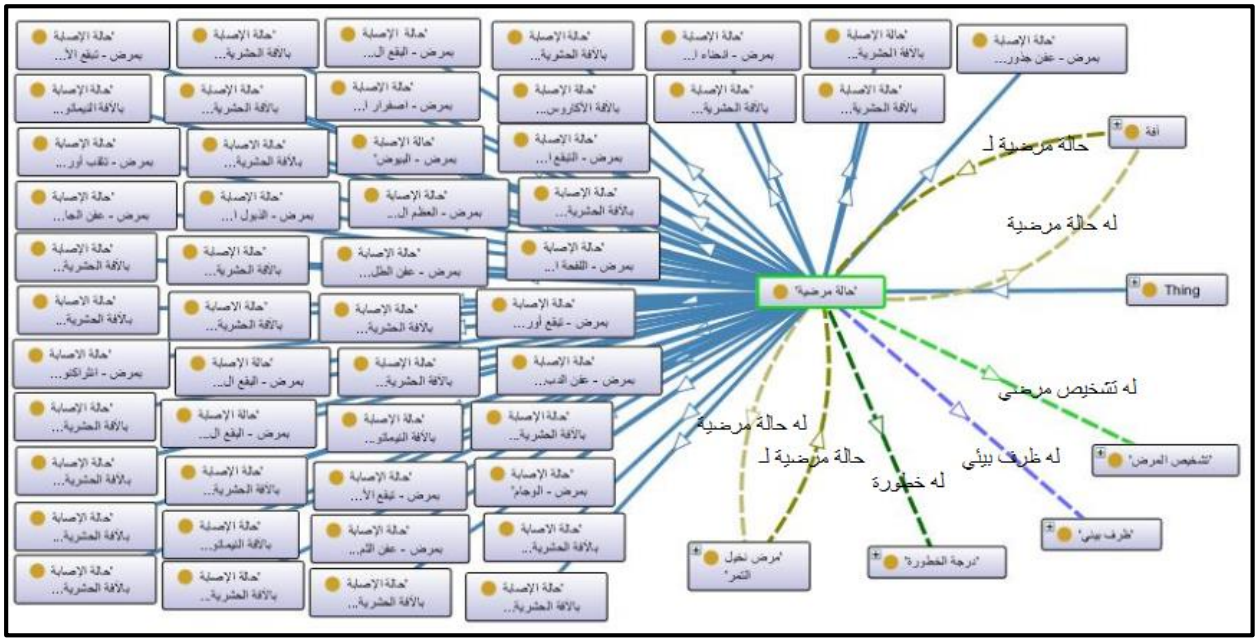

Figure A-13: Details of case of disease class

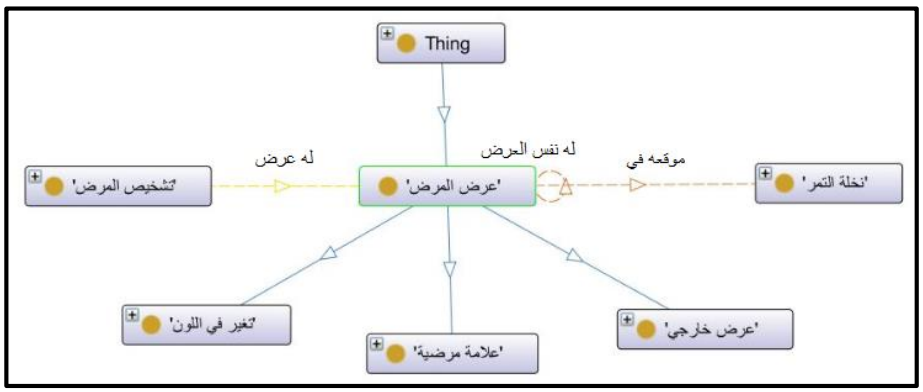

Figure A-14: Details of disease symptom class

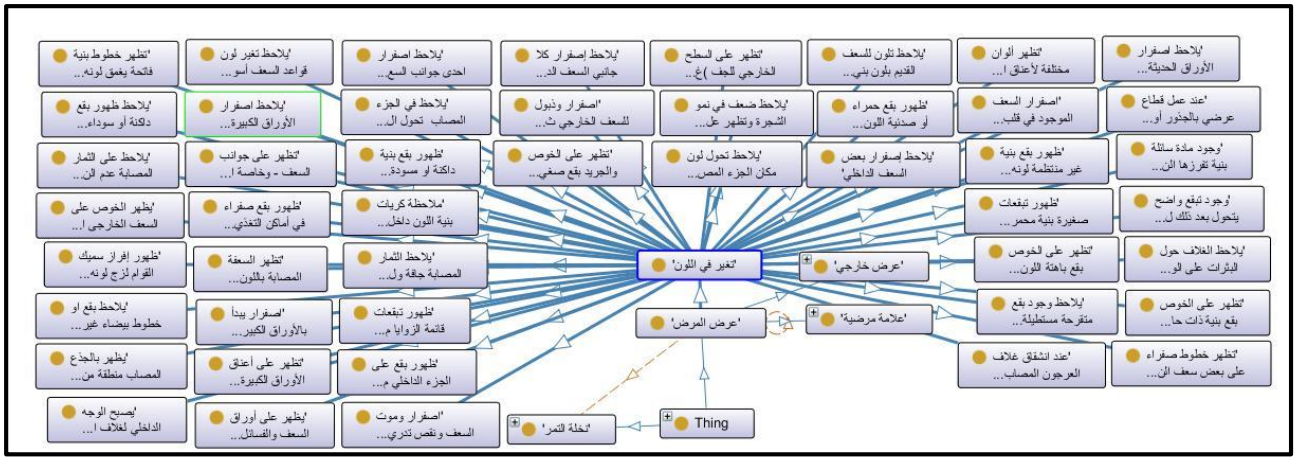

Figure A-15: Details of change color class

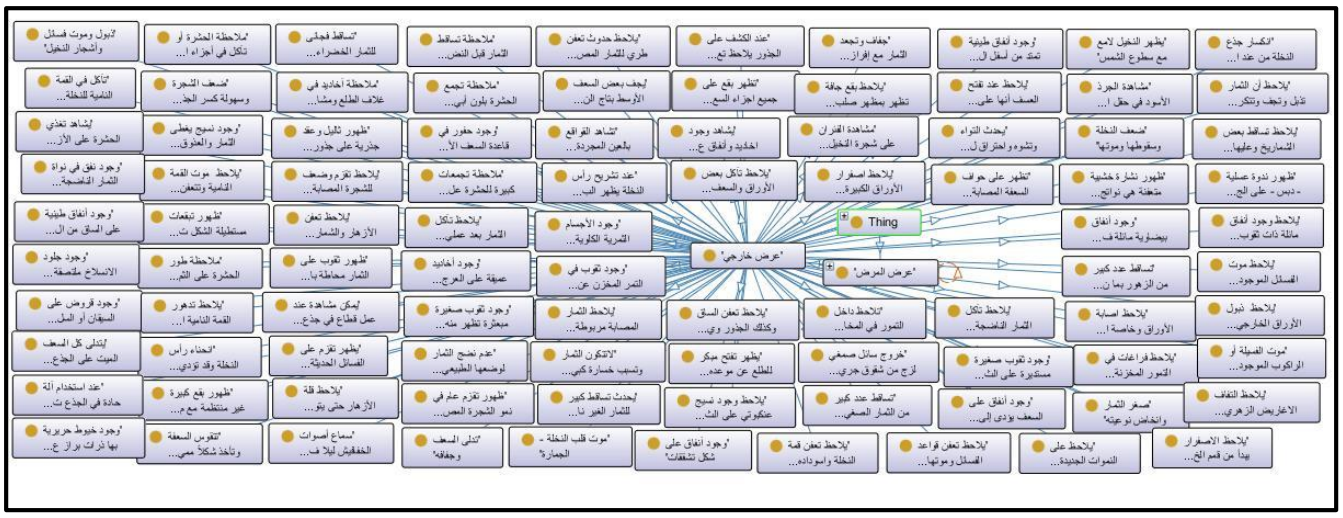

Figure A-16: Details of appearance class

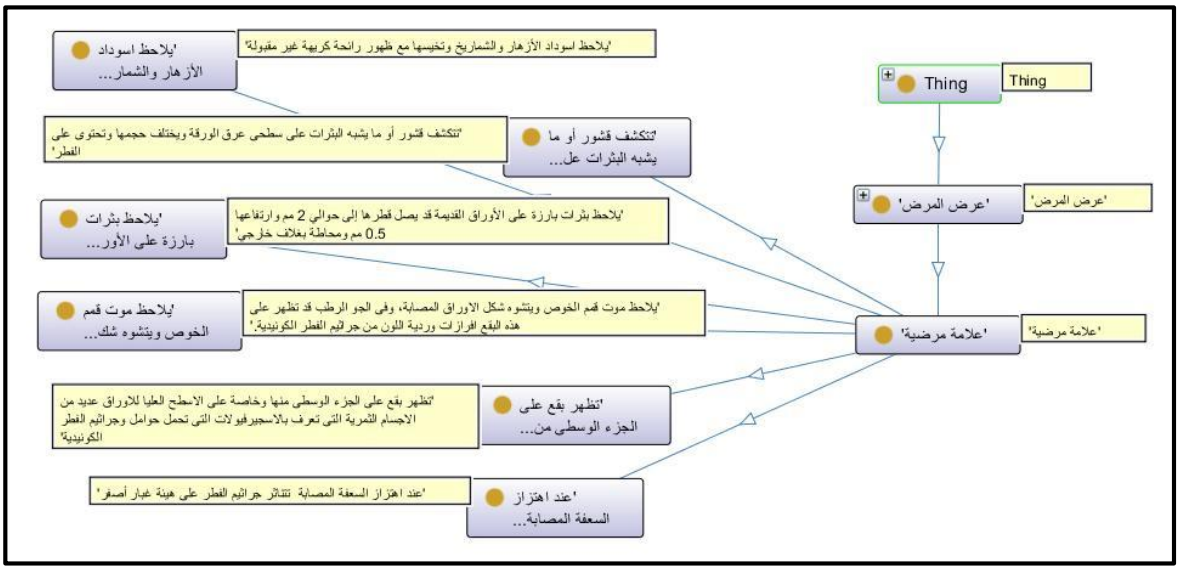

Figure A-17: Details of diseases sign class

Appendix B: Part of OWL Source Code

```
<?xml version="1.0"?>


<!DOCTYPE rdf:RDF [
   <!ENTITY owl "http://www.w3.org/2002/07/owl#" >
   <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >
   <!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >
   <!ENTITY ace_lexicon "http://attempto.ifi.uzh.ch/ace_lexicon#" >
   <!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >
   <!ENTITY  AgriDPOnto  "http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology"
>
   <!ENTITY                                                    AgriDPalmOntology
"http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#" >
]>

<rdf:RDF xmlns="&AgriDPOnto;#"
     xml:base="http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology"
     xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
     xmlns:owl="http://www.w3.org/2002/07/owl#"
     xmlns:ace_lexicon="http://attempto.ifi.uzh.ch/ace_lexicon#"
     xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
     xmlns:AgriDPOnto="http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology"
     xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
     xmlns:AgriDPalmOntology="&AgriDPOnto;#">
    <owl:Ontology
rdf:about="http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology">
       <rdfs:label rdf:datatype="&xsd;string">AgriDPOntology - An Ontology for Diagnosing Date
Palm Diseases.</rdfs:label>
       <rdfs:comment rdf:datatype="&xsd;string">Prepared By: Mahmoud El Askary
Supervisor: Dr. Rebhi Baraka</rdfs:comment>
       <rdfs:comment rdf:datatype="&xsd;string">أنطولوجيا تقوم على عملية تشخيص أمراض شجرة نخيل التمر ، 
وتحتوى على جميع الأمراض والأفات التي تسبب الضرر لنخيل التمر وطريقة العلاج المناسبة</rdfs:comment>
       <owl:versionInfo rdf:datatype="&xsd;string">الاصدار الأول - V 0.1</owl:versionInfo>
    </owl:Ontology>

    <!--
    ///////////////////////////////////////////////////////////////////////////////////
    //
    // Object Properties
    //
    ///////////////////////////////////////////////////////////////////////////////////
     -->

    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#case_of -->

    <owl:ObjectProperty rdf:about="&AgriDPOnto;#case_of">
       <rdf:type rdf:resource="&owl;FunctionalProperty"/>
       <rdfs:label rdf:datatype="&xsd;string">حالة مرضية من</rdfs:label>
       <ace_lexicon:TV_sg>case_ofs</ace_lexicon:TV_sg>
       <ace_lexicon:TV_pl>case_of</ace_lexicon:TV_pl>
       <ace_lexicon:TV_vbg>case_ofed</ace_lexicon:TV_vbg>
       <rdfs:domain rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
       <rdfs:range rdf:resource="&AgriDPOnto;#Pathogens"/>
```

```
    <owl:inverseOf rdf:resource="&AgriDPOnto;#has_case"/>
</owl:ObjectProperty>



<!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#factor_of -->

<owl:ObjectProperty rdf:about="&AgriDPOnto;#factor_of">
    <rdfs:label rdf:datatype="&xsd;string">مسبب مرضي من</rdfs:label>
    <ace_lexicon:TV_vbg>factor_ofed</ace_lexicon:TV_vbg>
    <ace_lexicon:TV_pl>factor_of</ace_lexicon:TV_pl>
    <ace_lexicon:TV_sg>factor_ofs</ace_lexicon:TV_sg>
    <rdfs:range rdf:resource="&AgriDPOnto;#Pathogens"/>
    <owl:inverseOf rdf:resource="&AgriDPOnto;#has_factor"/>
    <rdfs:domain>
        <owl:Class>
            <owl:unionOf rdf:parseType="Collection">
                <rdf:Description rdf:about="&AgriDPOnto;#Nutrients"/>
                <rdf:Description rdf:about="&AgriDPOnto;#Organism"/>
            </owl:unionOf>
        </owl:Class>
    </rdfs:domain>
</owl:ObjectProperty>



<!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#has_case -->

<owl:ObjectProperty rdf:about="&AgriDPOnto;#has_case">
    <rdf:type rdf:resource="&owl;InverseFunctionalProperty"/>
    <rdfs:label rdf:datatype="&xsd;string">لديه حالة مرضية</rdfs:label>
    <ace_lexicon:TV_vbg>has_cased</ace_lexicon:TV_vbg>
    <ace_lexicon:TV_pl>has_case</ace_lexicon:TV_pl>
    <ace_lexicon:TV_sg>has_cases</ace_lexicon:TV_sg>
    <rdfs:range rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
    <rdfs:domain rdf:resource="&AgriDPOnto;#Pathogens"/>
</owl:ObjectProperty>



<!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#has_factor -->

<owl:ObjectProperty rdf:about="&AgriDPOnto;#has_factor">
    <rdfs:label rdf:datatype="&xsd;string">لديه مسبب مرضي</rdfs:label>
    <ace_lexicon:TV_pl>has_factor</ace_lexicon:TV_pl>
    <ace_lexicon:TV_vbg>has_factored</ace_lexicon:TV_vbg>
    <ace_lexicon:TV_sg>has_factors</ace_lexicon:TV_sg>
    <rdfs:domain rdf:resource="&AgriDPOnto;#Pathogens"/>
    <rdfs:range>
        <owl:Class>
            <owl:unionOf rdf:parseType="Collection">
                <rdf:Description rdf:about="&AgriDPOnto;#Nutrients"/>
                <rdf:Description rdf:about="&AgriDPOnto;#Organism"/>
            </owl:unionOf>
        </owl:Class>
    </rdfs:range>
```

```
    </owl:ObjectProperty>


    <!--
    ///////////////////////////////////////////////////////////////////////////////////
    //
    // Data properties
    //
    ///////////////////////////////////////////////////////////////////////////////////
     -->



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Common_Name -->

    <owl:DatatypeProperty rdf:about="&AgriDPOnto;#Common_Name">
        <rdfs:label rdf:datatype="&xsd;string">اسم شائع</rdfs:label>
        <ace_lexicon:TV_pl>Common_Name</ace_lexicon:TV_pl>
        <ace_lexicon:TV_sg>Common_Names</ace_lexicon:TV_sg>
        <ace_lexicon:TV_vbg>Common_Named</ace_lexicon:TV_vbg>
        <owl:equivalentProperty rdf:resource="&AgriDPOnto;#name"/>
        <rdfs:range rdf:resource="&xsd;string"/>
        <rdfs:domain>
            <owl:Class>
                <owl:unionOf rdf:parseType="Collection">
                    <rdf:Description rdf:about="&AgriDPOnto;#Countries"/>
                    <rdf:Description rdf:about="&AgriDPOnto;#DP_Parts"/>
                    <rdf:Description rdf:about="&AgriDPOnto;#Organism"/>
                </owl:unionOf>
            </owl:Class>
        </rdfs:domain>
    </owl:DatatypeProperty>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Description -->

    <owl:DatatypeProperty rdf:about="&AgriDPOnto;#Description">
        <rdfs:label rdf:datatype="&xsd;string">الوصف</rdfs:label>
        <ace_lexicon:TV_pl>Description</ace_lexicon:TV_pl>
        <ace_lexicon:TV_sg>Descriptions</ace_lexicon:TV_sg>
        <ace_lexicon:TV_vbg>Descriptioned</ace_lexicon:TV_vbg>
        <rdfs:range rdf:resource="&xsd;string"/>
        <rdfs:domain>
            <owl:Class>
                <owl:unionOf rdf:parseType="Collection">
                    <rdf:Description rdf:about="&AgriDPOnto;#Environmental_Condition"/>
                    <rdf:Description rdf:about="&AgriDPOnto;#Problem_DP"/>
                </owl:unionOf>
            </owl:Class>
        </rdfs:domain>
    </owl:DatatypeProperty>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#name -->
```

```
    <owl:DatatypeProperty rdf:about="&AgriDPOnto;#name">
        <rdfs:label rdf:datatype="&xsd;string">الاسم</rdfs:label>
        <ace_lexicon:TV_sg>names</ace_lexicon:TV_sg>
        <ace_lexicon:TV_vbg>named</ace_lexicon:TV_vbg>
        <ace_lexicon:TV_pl>name</ace_lexicon:TV_pl>
        <rdfs:range rdf:resource="&xsd;string"/>
        <rdfs:domain>
            <owl:Class>
                <owl:unionOf rdf:parseType="Collection">
                    <rdf:Description rdf:about="&AgriDPOnto;#Countries"/>
                    <rdf:Description rdf:about="&AgriDPOnto;#DP_Parts"/>
                    <rdf:Description rdf:about="&AgriDPOnto;#Organism"/>
                </owl:unionOf>
            </owl:Class>
        </rdfs:domain>
    </owl:DatatypeProperty>


<!--
    ///////////////////////////////////////////////////////////////////////////////////
    //
    // Classes
    //
    ///////////////////////////////////////////////////////////////////////////////////
     -->

    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Cases_of_disease -->

    <owl:Class rdf:about="&AgriDPOnto;#Cases_of_disease">
        <rdfs:label rdf:datatype="&xsd;string">حالات مرضية</rdfs:label>
        <rdfs:subClassOf rdf:resource="&AgriDPOnto;#Plant_Protection"/>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&AgriDPOnto;#has_diagnosis"/>
                <owl:onClass rdf:resource="&AgriDPOnto;#Diagnosis_of_disease"/>
                <owl:qualifiedCardinality
rdf:datatype="&xsd;nonNegativeInteger">1</owl:qualifiedCardinality>
            </owl:Restriction>
        </rdfs:subClassOf>
        <rdfs:subClassOf>
            <owl:Restriction>
                <owl:onProperty rdf:resource="&AgriDPOnto;#case_of"/>
                <owl:onClass rdf:resource="&AgriDPOnto;#Pathogens"/>
                <owl:qualifiedCardinality
rdf:datatype="&xsd;nonNegativeInteger">1</owl:qualifiedCardinality>
            </owl:Restriction>
        </rdfs:subClassOf>
        <ace_lexicon:CN_sg>Cases_of_disease</ace_lexicon:CN_sg>
        <ace_lexicon:CN_pl>Cases_of_diseases</ace_lexicon:CN_pl>
    </owl:Class>




    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Control_methods -->
```

```
<owl:Class rdf:about="&AgriDPOnto;#Control_methods">
   <rdfs:label rdf:datatype="&xsd;string">طرق المكافحة</rdfs:label>
   <rdfs:subClassOf rdf:resource="&AgriDPOnto;#Plant_Protection"/>
   <rdfs:subClassOf>
      <owl:Restriction>
         <owl:onProperty rdf:resource="&AgriDPOnto;#name"/>
         <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:minCardinality>
      </owl:Restriction>
   </rdfs:subClassOf>
   <rdfs:subClassOf>
      <owl:Restriction>
         <owl:onProperty rdf:resource="&AgriDPOnto;#Description"/>
         <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:minCardinality>
      </owl:Restriction>
   </rdfs:subClassOf>
   <ace_lexicon:CN_sg>Control_methods</ace_lexicon:CN_sg>
   <ace_lexicon:CN_pl>Control_methodses</ace_lexicon:CN_pl>
</owl:Class>

<!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#DP_Parts -->

<owl:Class rdf:about="&AgriDPOnto;#DP_Parts">
   <rdfs:label rdf:datatype="&xsd;string">أجزاء نخلة التمر</rdfs:label>
   <rdfs:subClassOf>
      <owl:Restriction>
         <owl:onProperty rdf:resource="&AgriDPOnto;#name"/>
         <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:minCardinality>
      </owl:Restriction>
   </rdfs:subClassOf>
   <owl:disjointWith rdf:resource="&AgriDPOnto;#Plant_Protection"/>
   <ace_lexicon:CN_sg>DP_Parts</ace_lexicon:CN_sg>
   <ace_lexicon:CN_pl>DP_Partses</ace_lexicon:CN_pl>
</owl:Class>

<!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Plant_Disease -->

<owl:Class rdf:about="&AgriDPOnto;#Plant_Disease">
   <rdfs:label rdf:datatype="&xsd;string">أمراض نباتية</rdfs:label>
   <owl:equivalentClass>
      <owl:Class>
         <owl:intersectionOf rdf:parseType="Collection">
            <rdf:Description rdf:about="&AgriDPOnto;#Pathogens"/>
            <owl:Restriction>
               <owl:onProperty rdf:resource="&AgriDPOnto;#has_factor"/>
               <owl:allValuesFrom rdf:resource="&AgriDPOnto;#Microorganism"/>
            </owl:Restriction>
         </owl:intersectionOf>
      </owl:Class>
   </owl:equivalentClass>
   <rdfs:subClassOf rdf:resource="&AgriDPOnto;#Pathogens"/>
   <ace_lexicon:CN_pl>Plant_Diseases</ace_lexicon:CN_pl>
   <ace_lexicon:CN_sg>Plant_Disease</ace_lexicon:CN_sg>
</owl:Class>
```

```
    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Plant_Fungal -->

    <owl:Class rdf:about="&AgriDPOnto;#Plant_Fungal">
        <rdfs:label rdf:datatype="&xsd;string">أمراض فطرية</rdfs:label>
        <rdfs:subClassOf rdf:resource="&AgriDPOnto;#Plant_Disease"/>
        <ace_lexicon:CN_pl>Plant_Fungals</ace_lexicon:CN_pl>
        <ace_lexicon:CN_sg>Plant_Fungal</ace_lexicon:CN_sg>
    </owl:Class>

<!--
    ///////////////////////////////////////////////////////////////////////////////////
    //
    // Individuals
    //
    ///////////////////////////////////////////////////////////////////////////////////
     -->



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Appearance_1 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Appearance_1">
        <rdf:type rdf:resource="&AgriDPOnto;#Appearance"/>
        <rdfs:label rdf:datatype="&xsd;string">وجود آنفاق على شكل تشققات</rdfs:label>
        <image rdf:datatype="&xsd;string">Appearance\Appearance_1.jpg</image>
        <Description rdf:datatype="&xsd;string">وجود آنفاق على شكل تشققات واضحة قريبة من مصادر الري</Description>
        <ace_lexicon:PN_sg>Appearance_1</ace_lexicon:PN_sg>
        <location_in rdf:resource="&AgriDPOnto;#root"/>
    </owl:NamedIndividual>

    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Appearance_19 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Appearance_19">
        <rdf:type rdf:resource="&AgriDPOnto;#Appearance"/>
        <rdfs:label rdf:datatype="&xsd;string">موت قلب النخلة - الجمارة</rdfs:label>
        <image rdf:datatype="&xsd;string">Appearance\Appearance_19.jpg</image>
        <Description rdf:datatype="&xsd;string">موت قلب النخلة - الجمارة</Description>
        <ace_lexicon:PN_sg>Appearance_19</ace_lexicon:PN_sg>
        <location_in rdf:resource="&AgriDPOnto;#Gemara"/>
    </owl:NamedIndividual>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Appearance_23 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Appearance_23">
        <rdf:type rdf:resource="&AgriDPOnto;#Appearance"/>
        <rdfs:label rdf:datatype="&xsd;string">عدم نضج الثمار لوضعها الطبيعي وجفافها وسقوطها</rdfs:label>
        <Description rdf:datatype="&xsd;string">عدم نضج الثمار لوضعها الطبيعي وجفافها وسقوطها</Description>
        <ace_lexicon:PN_sg>Appearance_23</ace_lexicon:PN_sg>
        <location_in rdf:resource="&AgriDPOnto;#Bunch"/>
    </owl:NamedIndividual>
```

```
    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Appearance_89 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Appearance_89">
        <rdf:type rdf:resource="&AgriDPOnto;#Appearance"/>
        <rdfs:label rdf:datatype="&xsd;string"> يلاحظ تقزم وضعف للشجرة المصابة وغالبا يظهر سعف النخيل بشكل غير
طبيعي ويميل للاستقامة</rdfs:label>
        <Description rdf:datatype="&xsd;string"> يلاحظ تقزم وضعف للشجرة المصابة وغالبا يظهر سعف النخيل بشكل
غير طبيعي ويميل للاستقامة</Description>
        <location_in rdf:resource="&AgriDPOnto;#leaf"/>
        <location_in rdf:resource="&AgriDPOnto;#stem"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Appearance_9 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Appearance_9">
        <rdf:type rdf:resource="&AgriDPOnto;#Appearance"/>
        <rdfs:label rdf:datatype="&xsd;string">تدلى السعف وجفافه</rdfs:label>
        <Description rdf:datatype="&xsd;string">ملاحظة تدلى السعف وجفافه في النخلة المصابة</Description>
        <ace_lexicon:PN_sg>Appearance_9</ace_lexicon:PN_sg>
        <similar_problem rdf:resource="&AgriDPOnto;#Appearance_79"/>
        <location_in rdf:resource="&AgriDPOnto;#leaf"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Appearance_90 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Appearance_90">
        <rdf:type rdf:resource="&AgriDPOnto;#Appearance"/>
        <rdfs:label rdf:datatype="&xsd;string"> يظهر تفتح مبكر للطلع عن موعده الطبيعي ويقل عدد الأغاريض على
النخيل المصاب</rdfs:label>
        <Description rdf:datatype="&xsd;string"> يظهر تفتح مبكر للطلع عن موعده الطبيعي ويقل عدد الأغاريض على
النخيل المصاب</Description>
        <location_in rdf:resource="&AgriDPOnto;#Pollen"/>
    </owl:NamedIndividual>


    <!--
http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Arenipses_sabella_Hmps. -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Arenipses_sabella_Hmps.">
        <rdf:type rdf:resource="&AgriDPOnto;#Pest_Insect"/>
        <scientific_name rdf:datatype="&xsd;string">Arenipses sabella Hmps.</scientific_name>
        <factor_of rdf:resource="&AgriDPOnto;#The_Larger_date_moth"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Aspergillus_fumigatus
-->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Aspergillus_fumigatus">
        <rdf:type rdf:resource="&AgriDPOnto;#Fungus"/>
```

```
    <scientific_name rdf:datatype="&xsd;string">Aspergillus fumigatus</scientific_name>
    <factor_of rdf:resource="&AgriDPOnto;#Date_Fruit_Rot"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Bats -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Bats">
    <rdf:type rdf:resource="&AgriDPOnto;#Bats_Damage"/>
    <name rdf:datatype="&xsd;string">خفافيش</name>
    <Common_Name rdf:datatype="&xsd;string">وطاويط</Common_Name>
    <widespread_in rdf:resource="&AgriDPOnto;#Algeria"/>
    <has_case rdf:resource="&AgriDPOnto;#Case_59"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Egypt"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Iraq"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Jordan"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Kuwait"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Libya"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Morocco"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Oman"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Palestine"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Qatar"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Saudi_Arabia"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Sudan"/>
    <has_treatment rdf:resource="&AgriDPOnto;#Traditional_13"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Tunisia"/>
    <widespread_in rdf:resource="&AgriDPOnto;#United_Arab_Emirates"/>
    <widespread_in rdf:resource="&AgriDPOnto;#Yemen"/>
    <has_treatment rdf:resource="&AgriDPOnto;#chemical_31"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Case_11 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Case_11">
    <rdf:type rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
    <rdfs:label rdf:datatype="&xsd;string"> حالة الإصابة بالآفة الحشرية - حشرة النخيل القشرية
الحمراء</rdfs:label>
    <has_diagnosis rdf:resource="&AgriDPOnto;#Diagnosis_11"/>
    <has_condition rdf:resource="&AgriDPOnto;#High_Humidity"/>
    <has_dangerous rdf:resource="&AgriDPOnto;#Low"/>
    <case_of rdf:resource="&AgriDPOnto;#Red_date_Scale_insect"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Case_12 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Case_12">
    <rdf:type rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
    <rdfs:label rdf:datatype="&xsd;string">حالة الإصابة بالآفة الحشرية - بق النخيل الدقيقي</rdfs:label>
    <has_diagnosis rdf:resource="&AgriDPOnto;#Diagnosis_12"/>
```

```
        <has_condition rdf:resource="&AgriDPOnto;#High_Humidity"/>
        <case_of rdf:resource="&AgriDPOnto;#Mealy_Bugs"/>
        <has_dangerous rdf:resource="&AgriDPOnto;#Medium"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Case_13 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Case_13">
        <rdf:type rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
        <rdfs:label rdf:datatype="&xsd;string">حالة الإصابة بالآفة الحشرية - دوباس النخيل</rdfs:label>
        <case_of rdf:resource="&AgriDPOnto;#Date_Palm_Dubas_Bug"/>
        <has_diagnosis rdf:resource="&AgriDPOnto;#Diagnosis_13"/>
        <has_dangerous rdf:resource="&AgriDPOnto;#High"/>
        <has_condition rdf:resource="&AgriDPOnto;#High_Humidity"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Case_2 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Case_2">
        <rdf:type rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
        <rdfs:label rdf:datatype="&xsd;string">حالة الاصابة بالآفة الحشرية - النمل الأبيض</rdfs:label>
        <ace_lexicon:PN_sg>Case_2</ace_lexicon:PN_sg>
        <has_diagnosis rdf:resource="&AgriDPOnto;#Diagnosis_2"/>
        <has_condition rdf:resource="&AgriDPOnto;#High_Humidity"/>
        <has_dangerous rdf:resource="&AgriDPOnto;#Medium"/>
        <case_of rdf:resource="&AgriDPOnto;#Termites"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Case_20 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Case_20">
        <rdf:type rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
        <rdfs:label rdf:datatype="&xsd;string">حالة الإصابة بالآفة الحشرية - فراشة الدقيق الهندية</rdfs:label>
        <has_diagnosis rdf:resource="&AgriDPOnto;#Diagnosis_20"/>
        <has_condition rdf:resource="&AgriDPOnto;#High_Humidity"/>
        <case_of rdf:resource="&AgriDPOnto;#Indian_Meal_Moth"/>
        <has_dangerous rdf:resource="&AgriDPOnto;#Medium"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Case_21 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Case_21">
        <rdf:type rdf:resource="&AgriDPOnto;#Cases_of_disease"/>
        <rdfs:label rdf:datatype="&xsd;string">حالة الإصابة بالآفة الحشرية - الخنفساء ذات الصدر
المنشاري</rdfs:label>
        <has_diagnosis rdf:resource="&AgriDPOnto;#Diagnosis_21"/>
        <has_condition rdf:resource="&AgriDPOnto;#High_Temp"/>
```

```
    <has_dangerous rdf:resource="&AgriDPOnto;#Medium"/>
    <case_of rdf:resource="&AgriDPOnto;#Saw-Toothed_Grain_Beetle"/>
  </owl:NamedIndividual>


  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Color_1 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Color_1">
    <rdf:type rdf:resource="&AgriDPOnto;#Color"/>
    <rdfs:label rdf:datatype="&xsd;string">ملاحظة كريات بنية اللون داخل الأنفاق هي نواتج التغذية</rdfs:label>
    <Description rdf:datatype="&xsd;string"> ملاحظة كريات بنية اللون داخل الأنفاق هي نواتج
التغذية</Description>
    <ace_lexicon:PN_sg>Color_1</ace_lexicon:PN_sg>
    <location_in rdf:resource="&AgriDPOnto;#stem"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Color_10 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Color_10">
    <rdf:type rdf:resource="&AgriDPOnto;#Color"/>
    <rdfs:label rdf:datatype="&xsd;string"> يلاحظ على الثمار المصابة عدم النمو ويتحول لونها لبني
محمر</rdfs:label>
    <Description rdf:datatype="&xsd;string"> يلاحظ على الثمار المصابة عدم النمو ويتحول لونها لبني
محمر</Description>
    <location_in rdf:resource="&AgriDPOnto;#date"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Color_11 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Color_11">
    <rdf:type rdf:resource="&AgriDPOnto;#Color"/>
    <rdfs:label rdf:datatype="&xsd;string"> يلاحظ ضعف في نمو الشجرة وتظهر على الأوراق أعراض الذبول
والاصفرار</rdfs:label>
    <Description rdf:datatype="&xsd;string"> يلاحظ ضعف في نمو الشجرة وتظهر على الأوراق أعراض الذبول
والاصفرار</Description>
    <location_in rdf:resource="&AgriDPOnto;#leaf"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Color_12 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Color_12">
    <rdf:type rdf:resource="&AgriDPOnto;#Color"/>
    <rdfs:label rdf:datatype="&xsd;string"> يلاحظ وجود بقع متقرحة مستطيلة نوعا ما تبدأ صغيرة بنية اللون وتزداد
حسب شدة الإصابة</rdfs:label>
    <Description rdf:datatype="&xsd;string"> يلاحظ وجود بقع متقرحة مستطيلة نوعا ما تبدأ صغيرة بنية اللون وتزداد
حسب شدة الإصابة</Description>
    <location_in rdf:resource="&AgriDPOnto;#root"/>
  </owl:NamedIndividual>
```

```
    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Color_13 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Color_13">
        <rdf:type rdf:resource="&AgriDPOnto;#Color"/>
        <rdfs:label rdf:datatype="&xsd;string"> تظهر السعفة المصابة باللون الرمادي البني ثم تذبل حتى يصبح بعض
الخوص أو الأشواك من جهة باللون الأبيض</rdfs:label>
        <image rdf:datatype="&xsd;string">Color\Color_13.jpg</image>
        <Description rdf:datatype="&xsd;string"> تظهر السعفة المصابة باللون الرمادي البني ثم تذبل حتى يصبح بعض
الخوص أو الأشواك من جهة باللون الأبيض</Description>
        <location_in rdf:resource="&AgriDPOnto;#leaf"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Color_14 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Color_14">
        <rdf:type rdf:resource="&AgriDPOnto;#Color"/>
        <rdfs:label rdf:datatype="&xsd;string"> تظهر خطوط بنية فاتحة يغمق لونها على امتداد السطح السفلي للجريد والذي
يسمى بالسطح الظهري</rdfs:label>
        <Description rdf:datatype="&xsd;string"> تظهر خطوط بنية فاتحة يغمق لونها على امتداد السطح السفلي للجريد
والذي يسمى بالسطح الظهري</Description>
        <location_in rdf:resource="&AgriDPOnto;#leaf"/>
    </owl:NamedIndividual>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Diagnosis_14 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Diagnosis_14">
        <rdf:type rdf:resource="&AgriDPOnto;#Diagnosis_of_disease"/>
        <rdfs:label rdf:datatype="&xsd;string">تشخيص الإصابة بالآفة الحشرية - الجرد الصحراوي</rdfs:label>
        <observed_problem rdf:resource="&AgriDPOnto;#Appearance_32"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Diagnosis_15 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Diagnosis_15">
        <rdf:type rdf:resource="&AgriDPOnto;#Diagnosis_of_disease"/>
        <rdfs:label rdf:datatype="&xsd;string">تشخيص الإصابة بالآفة الحشرية - دودة البلح الصغرى</rdfs:label>
        <observed_problem rdf:resource="&AgriDPOnto;#Appearance_33"/>
        <observed_problem rdf:resource="&AgriDPOnto;#Appearance_34"/>
        <observed_problem rdf:resource="&AgriDPOnto;#Appearance_35"/>
        <observed_problem rdf:resource="&AgriDPOnto;#Color_9"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Diagnosis_16 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Diagnosis_16">
        <rdf:type rdf:resource="&AgriDPOnto;#Diagnosis_of_disease"/>
```

```
    <rdfs:label rdf:datatype="&xsd;string">تشخيص الإصابة بالآفة الحشرية - دودة البلح الكبرى</rdfs:label>
    <observed_problem rdf:resource="&AgriDPOnto;#Appearance_36"/>
    <observed_problem rdf:resource="&AgriDPOnto;#Appearance_37"/>
    <observed_problem rdf:resource="&AgriDPOnto;#Appearance_38"/>
    <observed_problem rdf:resource="&AgriDPOnto;#Appearance_39"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Diagnosis_17 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Diagnosis_17">
    <rdf:type rdf:resource="&AgriDPOnto;#Diagnosis_of_disease"/>
    <rdfs:label rdf:datatype="&xsd;string">تشخيص الإصابة بالآفة الحشرية - دودة ثمار الرمان</rdfs:label>
    <observed_problem rdf:resource="&AgriDPOnto;#Appearance_40"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Diagnosis_18 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Diagnosis_18">
    <rdf:type rdf:resource="&AgriDPOnto;#Diagnosis_of_disease"/>
    <rdfs:label rdf:datatype="&xsd;string">تشخيص الإصابة بالآفة الحشرية - دبور البلح</rdfs:label>
    <observed_problem rdf:resource="&AgriDPOnto;#Appearance_41"/>
  </owl:NamedIndividual>




  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Sign_4 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Sign_4">
    <rdf:type rdf:resource="&AgriDPOnto;#Diseases_Signs"/>
    <rdfs:label rdf:datatype="&xsd;string">تظهر بقع على الجزء الوسطى منها وخاصة على الاسطح العليا للاوراق
عديد من الاجسام الثمرية التى تعرف بالاسجيرفيولات التى تحمل حوامل وجراثيم الفطر الكونيدية</rdfs:label>
    <Description rdf:datatype="&xsd;string">تظهر بقع على الجزء الوسطى منها وخاصة على الاسطح العليا للاوراق
عديد من الاجسام الثمرية التى تعرف بالاسجيرفيولات التى تحمل حوامل وجراثيم الفطر الكونيدية</Description>
    <location_in rdf:resource="&AgriDPOnto;#leaf"/>
  </owl:NamedIndividual>



  <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Sign_5 -->

  <owl:NamedIndividual rdf:about="&AgriDPOnto;#Sign_5">
    <rdf:type rdf:resource="&AgriDPOnto;#Diseases_Signs"/>
    <rdfs:label rdf:datatype="&xsd;string">يلاحظ اسوداد الأزهار والشماريخ وتخيسها مع ظهور رائحة كريهة غير
مقبولة</rdfs:label>
    <Description rdf:datatype="&xsd;string">يلاحظ اسوداد الأزهار والشماريخ وتخيسها مع ظهور رائحة كريهة غير
مقبولة</Description>
    <location_in rdf:resource="&AgriDPOnto;#Inflorescence"/>
    <location_in rdf:resource="&AgriDPOnto;#Pollen"/>
    <location_in rdf:resource="&AgriDPOnto;#Raceme"/>
  </owl:NamedIndividual>
```

```
    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Sign_6 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Sign_6">
        <rdf:type rdf:resource="&AgriDPOnto;#Diseases_Signs"/>
        <rdfs:label rdf:datatype="&xsd;string"> يلاحظ موت قمم الخوص ويتشوه شكل الاوراق المصابة، وفى الجو الرطب
قد تظهر على هذه البقع افرازات وردية اللون من جراثيم الفطر الكونيدية.</rdfs:label>
        <image rdf:datatype="&xsd;string">Appearance\Appearance_68.jpg</image>
        <Description rdf:datatype="&xsd;string"> يلاحظ موت قمم الخوص ويتشوه شكل الاوراق المصابة، وفى الجو
الرطب قد تظهر على هذه البقع افرازات وردية اللون من جراثيم الفطر الكونيدية.</Description>
        <location_in rdf:resource="&AgriDPOnto;#leaf"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Sign_7 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Sign_7">
        <rdf:type rdf:resource="&AgriDPOnto;#Diseases_Signs"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Sign_8 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Sign_8">
        <rdf:type rdf:resource="&AgriDPOnto;#Diseases_Signs"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Sphaerodothus -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Sphaerodothus">
        <rdf:type rdf:resource="&AgriDPOnto;#Fungus"/>
        <scientific_name rdf:datatype="&xsd;string">Sphaerodothus</scientific_name>
        <factor_of rdf:resource="&AgriDPOnto;#Leaf_spot_Diamond"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Traditional_35 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Traditional_35">
        <rdf:type rdf:resource="&AgriDPOnto;#Traditional"/>
        <rdfs:label rdf:datatype="&xsd;string"> استخدام المصائد المزودة بالمواد الجاذبة ( شرائح بطاطس – نباتات قديمة
أزهار متساقطة – أوراق كرنب )لجذب القواقع ثم تجمع يوميا في الصباح الباكر وتقتل إما بوضعها في ماء مغلي أو محلول ملحي
قوى</rdfs:label>
        <Description rdf:datatype="&xsd;string"> استخدام المصائد المزودة بالمواد الجاذبة ( شرائح بطاطس – نباتات
قديمة أزهار متساقطة – أوراق كرنب )لجذب القواقع ثم تجمع يوميا في الصباح الباكر وتقتل إما بوضعها في ماء مغلي أو محلول
ملحي قوى</Description>
        <treatment_of rdf:resource="&AgriDPOnto;#Cochicella_acuta"/>
    </owl:NamedIndividual>
```

```
    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Traditional_36 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Traditional_36">
        <rdf:type rdf:resource="&AgriDPOnto;#Traditional"/>
        <rdfs:label rdf:datatype="&xsd;string">استخدام انواع مختلفة من المصائد للسيطرة على القوارض</rdfs:label>
        <Description rdf:datatype="&xsd;string"> استخدام انواع مختلفة من المصائد للسيطرة على
القوارض</Description>
        <treatment_of rdf:resource="&AgriDPOnto;#Black_Rat"/>
        <treatment_of rdf:resource="&AgriDPOnto;#House_Mice"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Traditional_37 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Traditional_37">
        <rdf:type rdf:resource="&AgriDPOnto;#Traditional"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#Traditional_38 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#Traditional_38">
        <rdf:type rdf:resource="&AgriDPOnto;#Traditional"/>
    </owl:NamedIndividual>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#chemical_1 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#chemical_1">
        <rdf:type rdf:resource="&AgriDPOnto;#Chemical"/>
        <rdfs:label rdf:datatype="&xsd;string">طعم الزنك</rdfs:label>
        <Concentration rdf:datatype="&xsd;string">%5</Concentration>
        <name rdf:datatype="&xsd;string">طعم الزنك</name>
        <treatment_of rdf:resource="&AgriDPOnto;#The_mole_cricket"/>
    </owl:NamedIndividual>



    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#chemical_10 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#chemical_10">
        <rdf:type rdf:resource="&AgriDPOnto;#Chemical"/>
        <rdfs:label rdf:datatype="&xsd;string">مبيد السيفين</rdfs:label>
        <Concentration rdf:datatype="&xsd;string">%85</Concentration>
        <name rdf:datatype="&xsd;string">مبيد السيفين</name>
        <treatment_of rdf:resource="&AgriDPOnto;#Bark_Beetle"/>
        <treatment_of rdf:resource="&AgriDPOnto;#Pomegranate_Fruit_Butterfly"/>
        <treatment_of rdf:resource="&AgriDPOnto;#The_Frond_Borer"/>
        <treatment_of rdf:resource="&AgriDPOnto;#The_Larger_date_moth"/>
        <treatment_of rdf:resource="&AgriDPOnto;#The_Red_Palm_weevil"/>
```

```
    </owl:NamedIndividual>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#chemical_11 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#chemical_11">
        <rdf:type rdf:resource="&AgriDPOnto;#Chemical"/>
        <rdfs:label rdf:datatype="&xsd;string">مبيد ديازنون</rdfs:label>
        <Concentration rdf:datatype="&xsd;string">%10</Concentration>
        <Description rdf:datatype="&xsd;string">باستخدام مبيد ديازنون 10% محبب او مخلوط من كاربارايل ( السيفين)
+ نشارة خشب بنسبة 9:1 وذلك بوضع المبيد في قمم النخلة المصابة في انفاق الحشرات الكاملة بعد اخراجه وذلك لمنع اعادة اصابة
الآفة لنفس النخلة مرة اخر</Description>
        <name rdf:datatype="&xsd;string">مبيد ديازنون</name>
        <treatment_of rdf:resource="&AgriDPOnto;#Rhinoceres_Beetle"/>
    </owl:NamedIndividual>


    <!-- http://www.semanticweb.org/jit/ontologies/2015/1/AgriDPalmOntology#chemical_12 -->

    <owl:NamedIndividual rdf:about="&AgriDPOnto;#chemical_12">
        <rdf:type rdf:resource="&AgriDPOnto;#Chemical"/>
        <rdfs:label rdf:datatype="&xsd;string">مبيد الملاثيون</rdfs:label>
        <Concentration rdf:datatype="&xsd;string">%15</Concentration>
        <Description rdf:datatype="&xsd;string">استخدام الرشاش ذات الضغط المرتفع للوصول إلى جميع أجزاء
المجموع الخضري للشجرة</Description>
        <Common_Name rdf:datatype="&xsd;string">مبيد الملاثيون</Common_Name>
        <treatment_of rdf:resource="&AgriDPOnto;#Date_Palm_Dubas_Bug"/>
        <treatment_of rdf:resource="&AgriDPOnto;#Date_Parlatoria_Scale_insect"/>
        <treatment_of rdf:resource="&AgriDPOnto;#Disert_Locust"/>
        <treatment_of rdf:resource="&AgriDPOnto;#Mealy_Bugs"/>
        <treatment_of rdf:resource="&AgriDPOnto;#Red_date_Scale_insect"/>
        <treatment_of rdf:resource="&AgriDPOnto;#The_Grean_Soft_Scale_insect"/>
        <treatment_of rdf:resource="&AgriDPOnto;#The_Lesser_date_moth"/>
    </owl:NamedIndividual>
```

Appendix C: Questions for testing the approach

تجربة للمقارنة بين النظام التقليدي والمحوسب في تشخيص أمراض نخيل التمر

المهندس الزراعي الخبير في مجال أمراض نخيل التمر :

أمامك مجموعة من الأسئلة والاستفسارات التي تتعلق بأمراض نخيل التمر ، الرجاء تعبئة الإجابة على كل سؤال في المكان المحدد ، مع تحديد الوقت المستغرق في الإجابة .

اسم المهندس الزراعي : يوسف شكري مصطفى الدوليمي .... العمر : 67 سنة ....

مدة الخبرة في المجال : 43 سنة .... مكان العمل: مزرعة نخيل بيروجات "1" ....

	Question- السؤال	Answer- الإجابة	الوقت
1	ما هو التشخيص المرضي للأعراض التالية: ١- ظهور افراز سميك القوام لزج لونه بني محمر ذو رائحة نفاذة ويسيل الافراز بكمية كبيرة على الجذع المصاب من الخارج. ٢- اصفرار السعف الموجود في قلب النخلة وتهدله.	١- سوسة النخيل الحمراء ٢- البوصيد الكاذب	2:30 د
2	ما هو التشخيص المرضي للأعراض التالية: ١- يلاحظ بثرات بارزة على الأوراق القديمة قد يصل قطرها إلى حوالي ٢ مم وارتفاعها ٠.٥ مم ومحاطة بغلاف خارجي. ٢- عند اهتزاز السعفة المصابة تتناثر جراثيم الفطر على هيئة غبار أصفر.	١- التفحم الكاذب "الجرافيوليا" ٢- التفحم الكاذب	1 د
3	ما هو التشخيص المرضي للأعراض التالية: ١- يلاحظ تعفن قمة النخلة واسوداد هو تفحم أنسجته وموت النخلة. ٢- يلاحظ تعفن الأزهار والشماريخ الزهرية داخل الطلع.	١- تعفن القلب "اللفحة السوداء" أو الجموتيت ٢- تعفن طلع النخيل "الخامج"	1 د
4	ما هو التشخيص المرضي للأعراض التالية: ١- يشاهد تغذي الحشرة على الأزهار في الطلع وخلو الشمراخ من الثمار. ٢- تعفن الأزهار والشماريخ الزهرية داخل الطلع.	١- دودة البلح الصغرى "الحميرة" ٢- تعفن طلع النخيل "الخامج"	2 د
5	ما هو التشخيص المرضي للأعراض التالية: ١- ملاحظة تجمع الحشرة بلون أبيض أو أحمر قرنفلي على الجزء المصاب مغطى بطبقة شمعية بيضاء. ٢- وجود نسيج يغطى الثمار والعذوق تلتصق به ذرات التراب ويكون ملمس الثمار خشن اوعند الضغط عليه يكون فليني	١- البق الدقيقي "أنواع مختلفة" ٢- حلم الغبار	3 د
6	ما هي اعراض مرض سوسة النخيل الحمراء ؟	- تحلل الخلايا الداخلية وتعفنها - جفاف الأوراق - وجود مادة لزجة ذات رائحة كريهة - الإصابة الشديدة إلى انكسار جذع النخلة لعوامل ميكانيكية.	2 د

7	ما هي أعراض مرض البيوض ؟	- يظهر على أحد جانبي الجريدة سعفة صفراء ممتدة على طول الورقة (أعلى إلى أسفل) أو تصبح صفراء كلها، ثم تحيط من الجانب الآخر أي تصبح الورقة صفراء تماماً.	2 د
8	ما هي أعراض مرض آفة اللحاء ؟		
9	ما هو العلاج الكيميائي المناسب لمرض آفة النمل الأبيض؟	- كونفيدور " تجريع في التربة "	3 د
10	ما هو العلاج الكيميائي المناسب لمرض آفة دوباس النخيل ؟	- كونفيدور " تجريع 5 سم³ للشجرة "	1 د
11	ما هو العلاج الحيوي المناسب لمرض سوسة النخيل الحمراء ؟	- تطبيق الحجر الزراعي	5 د
12	ما هو العلاج الحيوي المناسب لمرض البيوض	- زراعة فسائل جديدة / تعقيم الأرض / عدم نقل الأشجار الموبوءة / حرق الأشجار المصابة	4 د
13	من الأسماء الشائعة لآفة الحفار ؟	السوسة	1 د
14	من الأسماء الشائعة لآفة سوسة النخيل الحمراء ؟	الصرصور	2 د
15	ما هي خطورة مرض عفن طلع النخيل ؟	فشل في إنتاج حبوب اللقاح ...	2 د
16	ما هي خطورة مرض عفن الدبلوديا ؟	موت الفسائل	2 د
17	ما هي الظروف البيئية الملائمة لمرض اللفحة السوداء ؟	- وصول ماء الري لقلب الفسيلة	1 د
18	ما هي الظروف البيئية الملائمة لمرض الاصفرار الناتج عن نقص النيتروجين ؟	1. انخفاض PH عن 7 أو أعلى من 9	7 د
19	ما هي الأمراض الغير معروف مسببها المرضي؟	1. انحناء الرأس	8 د
20	التركيز المستخدم مع مبيد الدورسبان ؟	- حشرة النخيل القشرية الحمراء 2.5 سم/لتر - الحميرة 2 سم/لتر - حشرة الدوباس 2 سم/لتر	6 د

انتهت الأسئلة

الباحث / محمود العسكري

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Appendix D: Photo album of visiting Fayhaa City (City of the Million Palms)

Figure D-1: Palm City entrance

Figure D-2: A Palm in the City

Figure D-3: View of the Palm City

Figure D-4: Burning trees contaminated by pests

Figure D-5: Burning trees contaminated by pests