ISSN 2047-3338

An Ontology-Driven Decision Support System for Wheat Production

Sahjanan Yousef Mawardi[1], Mohamed Hashem Abdel-Aziz[2], Ahmed Mohamed Omran[3] and Tarek Ahmed Mahmoud[4]
[1]Military Technical College, Egypt
[2]Faculty of Computers and Information, Ain Shams University, Egypt
[3]Faculty of Computers and Information, Fayoum University, Egypt
[4]Egyptian Armed Forces
wailwail69@yahoo.com, jane.doe@email.com, jane.doe@email.com

***Abstract*– This paper presents an ontology-driven decision support system for Syrian Wheat production. Wheat is the most important staple food commodity in the country and is consumed primarily as bread. It is also the country's only strategic food security commodity, and is treated accordingly. This paper also aims to develop criteria for Wheat production ontology and concentrates on Wheat diseases, control methods, Wheat issues and strategies. Rule-based reasoning system and ontology proved to be able to cope with some difficulties and to face several problems related to Wheat domain. The developed ontology would be a knowledge base and a role stone for advanced research knowledge management in Wheat domain. Moreover, it is so important for the decision makers to know the opportunities to capture them and to avoid the threats that could negatively affect the Wheat production.**

***Index Terms*– Wheat production, Ontology, Rule based System and Decision Support System**

I. INTRODUCTION

THE agriculture sector plays an important role in Syrian's economy. Wheat is the most important staple strategic crop. Syria has been essentially self-sufficient in Wheat production for the past 20 years, with the infrequent exception of seasons when severe drought prevails (e.g. in 2008). Wheat self-sufficiency has been a major policy objective of the government, which over the years encouraged the expansion of sown area and the development of increased irrigation infrastructure to ensure production growth kept pace with gradually increasing domestic consumption. Because of its importance, Wheat is considered a strategic resource in Syria. Syrian farmers cultivate both hard (durum) and soft Wheat varieties [1].

Wheat is subjected to many diseases at nearly all stages of growth. Because diseases reduce yield and grain quality, they directly affect the profitability of grain cultivation. To effectively control Wheat diseases, the following strategies should be considered: the selection of resistant varieties of disease, the use of fungicide seed dressing, crop rotation, deep tillage, proper fertility, and the application of foliar fungicides. Early identification of diseases is critical to select the correct disease management process. Rust is the most common disease, leaf rust for example caused by Puccinia recondite tritici, and stem rust, caused by Puccinia graminis tritici, leaf rust may cause a yield loss of more than 50 percent on susceptible variety of Wheat, but damage is usually lower [2].

Unfortunately, the research knowledge repositories for Wheat production and also plant production in Syria are not well organized and utilized. This in turn is a main obstacle for making use of previous studies, and for research objectives. Representing knowledge of any domain is an important step, and could be a basis for recording, retrieving, processing, sharing and also acquiring knowledge. It is believed that organizing information about the Wheat production, policies, issues, strategies and diseases can play important roles in providing solutions to the problems. For Wheat diseases, suggestions and control methods could be given about each kind of disease, also alternative solutions are introduced. Thus, strategies to decision makers to help open their minds to all the scenarios that could happen in the future are provided. So, the government need as efficient and effective as possible technology of managing, reusing, and sharing knowledge about Wheat production process.

One can use Semantic Web technology to considerably improve information representation as it is a simple way of representing the relationships between entities and concepts (classes) in the form of hierarchies [3]. Several knowledge representation techniques can also be used such as frames, uncertain reasoning, ontology and rules, etc. [3], [4]. Not all these mechanisms are appropriate for knowledge representation in complex systems. Semantic networks or frames are not appropriate, as they only let to use declarative statements that are true or false. Semantic networks are a classic representation technique for declarative knowledge and they consists of nodes (objects, concepts, situations) and arcs (relationships between them). Actually, semantic networks are shallow knowledge structures where all knowledge are contained in nodes and links, to represent definitive knowledge, the link and node names must be rigorously defined. A solution to this is extensible markup language (XML) and ontology. Problems also include combinatorial explosion of searching nodes, inability to define knowledge the way logic can, and heuristic inadequacy [5].

Moreover, frames are useful for simulating commonsense knowledge (knowledge that is generally known) about narrow subjects like the semantic networks. These subjects are much default knowledge and problems with frames include allowing unrestrained alteration and cancellation of slots. The same thing applies to uncertainty reasoning [6], which provides solutions for situations whether a true or false cannot be got, and may be led to conflict with complex systems.

Rule-based expert systems and ontologies proved to be able to cope with some known difficulties and to find solutions to several problems. Nowadays, the trends are to represent knowledge using rules and ontologies. Ontologies provide a shared and common understanding of a domain and play a critical role in knowledge creation process and knowledge management process. Ontology describes a particular domain model that contains the terms referring to a cooperation, which must be distinguished as categories in the domain knowledge model. Protégé is an open source ontology editing tool supporting SWRLTab plug-in to help editing Semantic Web Rule Languages (SWRL) rules. Rule-based Reasoning is integrated with domain ontology to provide a mechanism of integration among different reasoning paradigms for knowledge processing, inference, representation and sharing among a group of participators. Weighted Real-Time Delphi (*WRT-Delphi*) is used online for collecting and acquiring data from experts according to questionnaire based on some criteria for Wheat production ontology construction. Moreover, WRT-Delphi is used for validating the created criteria with support of domain experts. This paper was inspired by the rice production ontology proposed in [7].

This paper discusses building ontology for Wheat production, the criteria for building ontology to deal with Wheat diseases and their control methods. Moreover, the strategies for Wheat program in Syria are introduced, as they are responsive to the new emerging issues, trends, events under the present scenario. Some of the important issues, trends, events which are able to be addressed in the coming years are discusses in details in [8]. The system can act as a powerful tool in agriculture as it provides aid when specialist and expert assistance is not readily available when the farmers and decision makers need it. The remainder of this paper is organized as follows: Section 2 presents WRT-Delphi questionnaire and criteria. Section 3 discusses Syrian Wheat strategies and issues. Section 4 is dedicated to show some Wheat diseases and control methods. In section 5 an ontology-driven knowledge representation is introduced. Finally, conclusion and recommendations for further and advance research are demonstrated in section 6.

II. WRT-DELPHI QUESTIONNAIRES AND CRITERIA

The Delphi technique originally developed by the RAND Corporation for technological forecasting in 1960s, and was later enhanced by U.S. government for group decision-making [9]. Traditional Delphi method is based on a number of sequential rounds of questionnaires for eliciting knowledge from a group of experts, who are anonymous to each other. After each round a feedback of statistics such as median, group judgments are given in addition to arguments, variables, trends, and counter forces [7]. The rationale behind the Delphi method is to address and overcome the disadvantages of traditional methods of consultation by large-scale participators, particularly those related to group dynamics.

WRT-Delphi analysis is actually a round-less RT-Delphi technique enhanced by weighting the experts' opinions according to some attributes (experience, number of participating in the study), and done online. It is an essential mechanism in eliciting knowledge, listing variables, factors, trends, forces, evaluating the probabilities of events occurrence.

It provides statistical information based on the following:

- The analysis technique is a matrix in which rows represent previously stated criteria which in fact are weighted criterions and columns represent the degree of agreement.
- Each cell in the matrix has its own statistics which in turn dynamically updated online and expresses the degree to which rows meet the columns according to a weighted list.

WRT-Delphi is a good results-based and expert-based questionnaire. Criteria, for building the Wheat Production Ontology introduced in the questionnaire, have been derived from literature review on Wheat production. The sources for knowledge are texts and research documents both in Arabic and English together with experts' opinions. Contents were summarized into the format that suitable for ontology construction. Some criteria for developing Wheat production ontology are:

1. Criteria for defining concepts of Wheat production process.
2. Criteria for defining terms.
3. Criteria for defining relationships.

Figure 1 illustrates an example of a research questionnaire of Wheat production. Statistics should be done according to the range of responses received; all of these criteria and the degree of agreements are summarized. This is in turn conforms an important step for building Wheat ontology.

III. WHEAT STRATEGIES AND ISSUES

Syrian agriculture must continuously evolve taking into account previous experience in addition to future visions to manage the change, to capture the opportunities and to avoid the threats that may threaten the agriculture sector. In [8] the environmental scanning is done as collectively and participatory as possible to explore, create, and test both possible and desirable futures to capture opportunities of the futures images, trying to optimize them, and at the same time to avoid or reduce the risks of future threats. Strengths, weaknesses, opportunities, and threats must be analyzed in depth to put our research efforts to serve decision makers and

How much do you agree with the following criteria in the Wheat production process

No.	Criteria	Degree of agreement				
		5	4	3	2	1
1	Process of wheat production					
1.1	Wheat cultivation (from planting to harvesting)					
1.2	Soil classification					
1.3	Irrigation process					
1.4	Fertilizing process					
1.5	Propagation					
1.6	Seed production and processing					
1.7	Genetics and breeding					
1.8	Cropping system					
1.9	Wheat pest control					
1.1	Wheat disease and control process					
1.11	Weed control					
1.12	Other, please define					

Suggestion --

Please mark in the opinion cell as you see appropriate, based on the following score meaning

5 means you are strongly agree with the given issue
4 means you are very much agree with the given issue
3 means you are moderately agree with the given issue
2 means you are slightly agree with the given issue
1 means you are weakly agree with the given issue

Fig. 1: Wheat Production Process Questionnaire

help them to face the emerging problems, to introduce advices, suggestions and solutions. Actually, Decision Support Systems (DSSs) are typically used for strategic and tactical decisions faced by upper-level management decisions with a reasonably low frequency and high potential consequences in which the time taken for thinking through and modeling the problem pays off generously in the long run. Also DSS has important impacts on strategic planning and strategic management process. In this paper, we are not talking about the architecture of our developed DSS and its components, but we focus on the knowledge-based components in section 5.

For achieving the Wheat production targets, long-term strategies must be identified and implemented. As Wheat domain in Syria is analyzed using PESTEEL and SWOT analysis [8]. A list of 40 variables, events, trends that affects this domain is extracted as strengths, weaknesses, opportunities, and threats. Also the relationships among these 40 variables are studied in more details in [8]. This means that the government should take into account these events, trends to draw its policy and put its strategies to enhance the strengths, capture the opportunities as well as minimizing the effects of threats and trying to optimize and overcome the obstacles and problems due to weaknesses.

For example, one of the threats for Syrian Wheat Production is Global climatic change, and the suggested strategies will be as inspired from [10]:

- Revisit the sowing time and seeding procedures.
- Intercropping of tall and short crops to moderate the micro-climate by shading.
- Surface residue retention for temperature moderation and water conservation.
- Identify/develop short duration varieties having tolerance to early and late heat.

This is actually embedded in the ontology-driven knowledge base. Furthermore, in section 5 we will focus on some of these strategies as it is stored in long-term memory.

IV. WHEAT DISEASES AND CONTROL METHODS

Wheat is subjected to many damaging foliar, soil and seed-borne diseases at nearly all stages of growth [2]. Some of these diseases are caused by fungi, bacteria, and viruses. Wheat is one of the most critically important staple foods worldwide. Its harvests have come under increasing years from new kinds of fungus infections, such as Wheat rusts, that are killing these crops. Wheat rust is well known to farmers and agricultural planners around the world. They have been dealing with it since the early 1900. But in the past decade, new races have emerged that are overcoming the Wheat crops that had been resistant to these rusts.

Wheat rust diseases are well known in the world's developing countries. These countries have successfully managed rusts over the past decades using disease-resistant Wheat varieties. Today the situation and the threat from Wheat rust are fundamentally different from the past. Changes in temperature and rainfall patterns have encouraged the emergence of new races of rust that overcome the currently resistant Wheat varieties. Actually, there are three important types of rust diseases that affect Wheat crops [11]:

- Strip Rust that is called the yellow rust.
- Stem Rust that is called the black rust.
- Leaf Rust that is called the brown rust.

These diseases have their own control methods, and the breeding of disease-resistant Wheat varieties is the chief line of long-term defense for Wheat crops against stripe rust, and in fact, for all rust diseases. Disease resistance can be built into Wheat, but the development cycle is typically about ten years (ten generations of breeding and testing resistance in a new variety) for new varieties to be released and made available to farmers [11]. Furthermore, foliar fungicides can provide good rust control.

In this paper, the proposed ontology will focus on some Wheat-diseases and their control methods and management processes.

V. ONTOLOGY-DRIVEN KNOWLEDGE REPRESENTATION

Knowledge representation methods are important for the description of any domain, as they are express formalization of the knowledge. These methods are important in enabling the automatic processing of knowledge about the domain. However, these methods are not suitable for all applications. The most known knowledge representation methods are: predicated logic, production rules, frames, semantic network, object-oriented method, uncertain reasoning, ontology and so on [3].

In recent years, there has been a considerable progress in developing the conceptual bases for building ontologies. In Artificial Intelligence (AI), many definitions have been introduced to ontology, one of them is [12]: "An ontology is an explicit specification of a conceptualization", and this is the most popular and widely used in the ontology research. Ontologies have been developed in AI to facilitate knowledge sharing and reuse. It is used to provide a shared and common understanding of a domain which can be communicated among participants, experts and people. Nevertheless, ontology represents an explicit conceptualization that describes the semantics of data [13].

Ontology is used to capture knowledge about some domain of interest. The ontology describes a particular domain model that contains the terms referring to a cooperation, which must be distinguished as categories in the domain knowledge model. Ontology describes the concepts in the domain and also the relationships that hold between these concepts. Different ontology languages provide different facilities.

The ontology structure O is defined as adapted from [14], [15]:

O = {C, R, A^O},

Where:

1. C is a set of concepts (classes).
2. R ⊆ C ×C a set of relationships connecting concepts (Directed edges in graph).
3. A^O is a set of axioms on O.

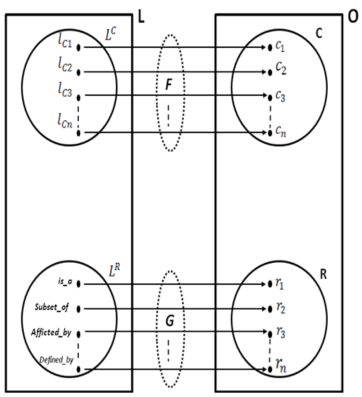

Fig. 2: Ontology Graph Structure

Figure 2 illustrates the structure of ontology graph, a lexicon L is defined as:

L = {L^C,L^R, F, G}, where:

1. L^C is a set of lexical entries for concepts.
2. L^R is a set of lexical entries for relations.
3. F ⊆ L^C×C is a reference for concepts such that
   F (l_C) = {c∈ C : (l_C, c) ∈ F}for all l_C∈ L^C ,
   $F^{-1}(c)$ = {l_C ∈ L^C: (l_C, c) ∈ F} for all c ∈ C.
4. G ⊆ L^R × R is a reference for relations such that
   G (l_R) = {r ∈ R: (l_R, r)∈ G} for all l_R ∈ L^R,
   G^{-1} (r) = {l_R ∈ L^R: (l_R, r)∈ G } for all r ∈ R.

After the ontology scope and composition are mostly clear, classes and their hierarchies have to be specified as entirely as possible. The class hierarchy represents an "is-a" relation: If a class A is a super class of class B, then every instance of B is also an instance of A. Accordingly, an ontology - as a knowledge representation - is used in modeling Wheat production process. The proposed ontology consists of two levels: level one can be used by any application for long-term strategic planning as it encompasses concepts to define SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats analysis) with its two components (Internal Factor Evaluation Matrix (IFE), and External Factor Evaluation Matrix(EFE)). Actually, this level could be ready-made sub-ontology. Level two is domain specific as it concentrates on Wheat domain such as Wheat diseases and their control methods, Wheat growth stages, etc. Conceptually, this level is custom-made sub-ontology. The resulting ontology could be used in other applications within the context of ontology reusability. Building the ontology knowledge base (KB) components consists of two parts, which are ontology KB model and ontology building editor. According to what have been mentioned previously, an ontology building module is used to manage formal domain sub-ontologies, which are: model variables, model drivers, policies, participants (experts, decision makers, and analysts), WRT-Delphi questionnaires, SWOT analysis factors, etc.

The main components of ontology are concepts and relations among these classes. Classes or concepts can be organized with a class hierarchy, including super classes and subclasses concepts. Relationships between classes (concepts) can be grouped in two main groups: hierarchical relationships and associative relationships. Hierarchical relationship identifies the hierarchy between super-classes, subclasses. Associative relationship connects concepts which are not in the same hierarchy [7].

Figures 3 and 4 illustrate Wheat ontology concepts (classes), and Wheat ontology relationships respectively.

A) Ontology KB Model

Ontology might be stored in a knowledge repository for a specific domain to improve its scalability, performance, querying and modification facilities. Most part of ontology modeling tools and repositories provide API for improving these facilities.

It is also very important to mention that the ontology KB archives and documents: all the best practice experiences and expertise of organizations and enables their further use for different purposes.

Moreover, the ontology KB is created in order to enhance and provide additional semantic to the relationships of the domain concepts. Furthermore, the primary task of the proposed ontology is to add meaningful semantic to data used and to provide high quality information for the end-users.

After the ontology KB is built, it is very important to consider how the created ontology could be stored. Ontology repositories enable storage of large ontologies. They provide better ontology integration, maintenance and querying options as well as improved scalability and performance facilities. Simple ontologies with low integration and maintenance requirements might be stored in files as well.

B) Ontology Building Editor

Ontology approach provides the most expressive power for the real world information modeling. If the ontology is well defined and its powerful concepts are used, new knowledge can be inferred and provided by ontology reasoners. Reasoners are also able to perform complex ontology queries to derive necessary information.

Protégé 3.3.1 ontology editor is selected to develop the proposed ontology conceptual design and afterwards to build

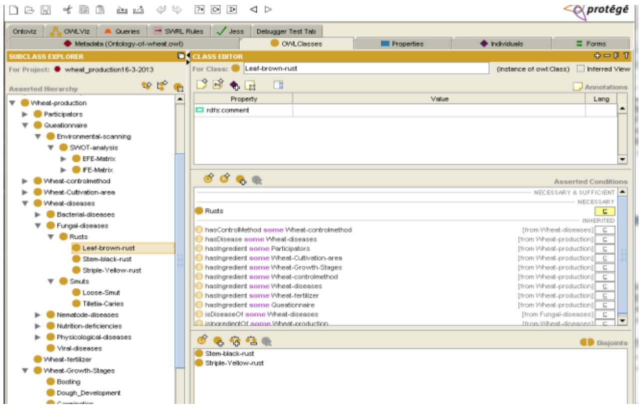

Fig. 3: Wheat Ontology Concepts

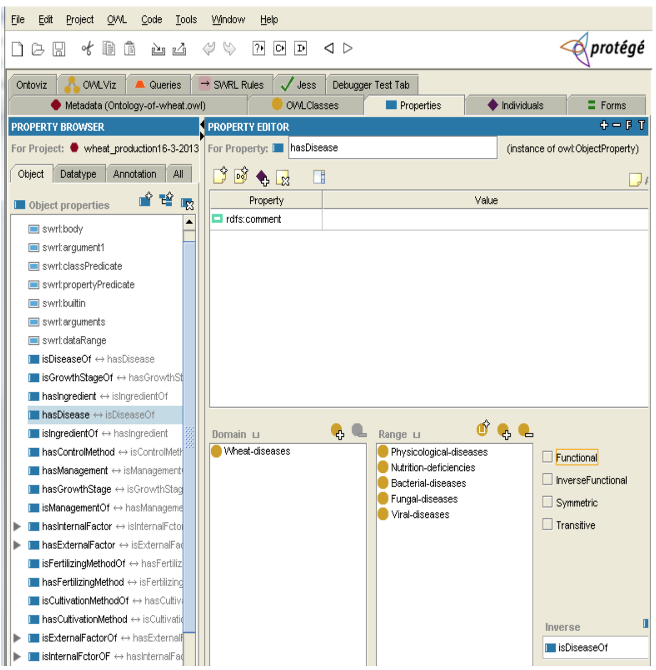

Fig. 4: Wheat Ontology Relationships

the ontology KB required for the Wheat production domain. To specify the proposed ontology concepts in expressive way the Ontology Web Language (OWL) editor is used. The OWL editor fits the semantic web requirements and needs and represents an extension of Protégé ontology editor.

Furthermore, OWL editor is able to integrate already existing plug-ins (ontology testing, querying, integrating services) to customize the OWL ontology development tool and its power to the developers' needs. Protégé might be used to store large ontologies, multi-user mode based on client/server architecture and might be reused for collaborative working.

The Protégé-OWL editor enables users to: load and save OWL and RDF (Resource Description Framework) ontologies, edit and visualize classes, properties, and SWRL rules, define logical class characteristics as OWL expressions, execute reasoners such as description logic classifiers, edit OWL individuals for Semantic Web markup [16].

C) Rule-Based Systems

Natural forms of expressing knowledge in some domain of interest are *rules* that reflect the notion of consequence. All rules in the knowledge base follow the format:

IF (*Conditions*) *THEN Actions*

The IF-part is also called the conditions part, and the THEN-part is also called the resulting action or goal part. When conditions are fulfilled then the resulting action (conclusion) is executed. Rule-based system, ontology proved to be able to cope with some difficulties and problems related to Wheat domain. SWRL editor is used as it leaps the limitations of both ontology and rules. Ontology and rules in the knowledge base are integrated so Racer for ontology-based inference, and Jess (Java Expert System Shell) for rule-based reasoning are used.

Racer is used to complete ontology consistency, concept based classification and other ontology based inference task [16]. On the other hand, Jess rule engine is a tool uses lisp-like syntax to describe the rules and facts, and can through these rules inference facts. The conversion from knowledge base format -which is based on both ontology and rules- to Jess is done with the help of SWRLTab plug-in. The SWRLTab has four main software components: (1) a SWRL graphical editor; (2) a SWRL API which provides a collection of Java APIs for working with SWRL rules; (3) a rule engine bridge that provides a bridge between an OWL model with SWRL rules and a rule engine. Its goal is to interoperate with rule engines to execute SWRL rules; and (4) a SWRL built-in bridge for defining and executing implementations of SWRL built-ins. These implementations can then be dynamically loaded by the bridge and invoked from a rule engine [17].

The rules are written using SWRL syntax, which only uses conjunction symbol (^) and the implication symbol ($\longrightarrow$), and variables of the condition part of IF statement, syntax for classes, instances, properties. The rule variables are represented by the interrogation symbol (?). The class atoms are constructed from an OWL class name followed by one variable or individual name in parenthesis, e.g. Wheat-diseases (?x). The individual property atom are constructed from an OWL object property name followed by two arguments in the parenthesis, e.g., hasDisease(?x,?y). Also data property atoms are represented in the same way. The SWRL built-ins used in this paper such as swrlb:lessThanOrEqual(WG_Zadoks, 9), which means the rule variable WG_Zadoks less than or equal to 9. For example, the SWRL rule syntax of Wheat ontology may be like this:

Fungal-diseases(?x) ∧ WD_Color(?x, ?y) ∧ WD_Season(?x, ?z) ∧ WD_Stage(?x, ?m) ∧ WD_Section(?x, ?a) ∧ WD_Part_becomes(?a, ?b) ∧ WD_Disease_becomes(?x, ?c → Smuts(?x) ∧ hasControlMethod(?x, ?y)

Which means that:

IF (Disease is fungal) and (Disease color is light_green_to_grey_black) and (season is spring) and (stage is early) and (problem is in leaves) and (leavesbecomes rolled_twisted) and (disease becomes weekened-frayed)

THEN

the disease is flag smuts and has a control method

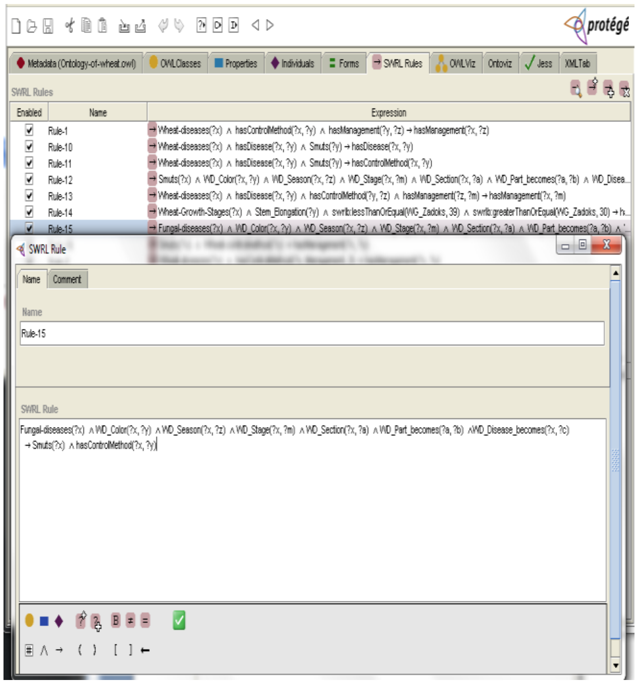

Fig. 5: SWRL Rules Syntax of Wheat Ontology

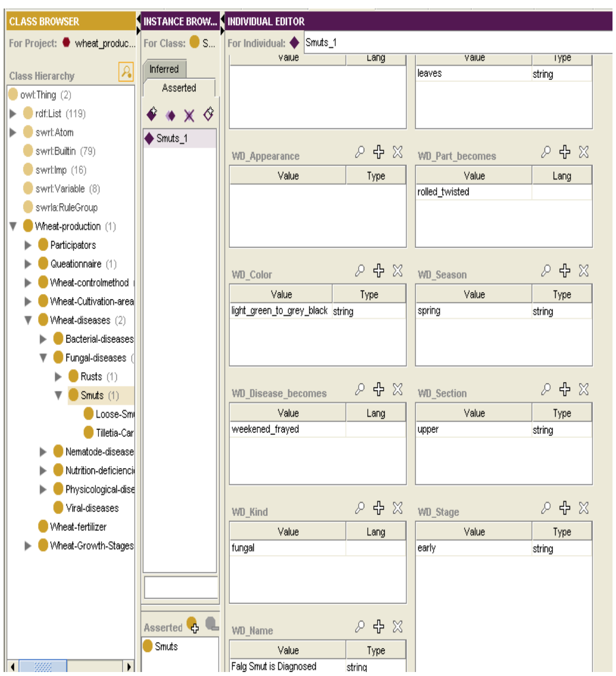

Fig. 6: Attributes of the Smut Disease

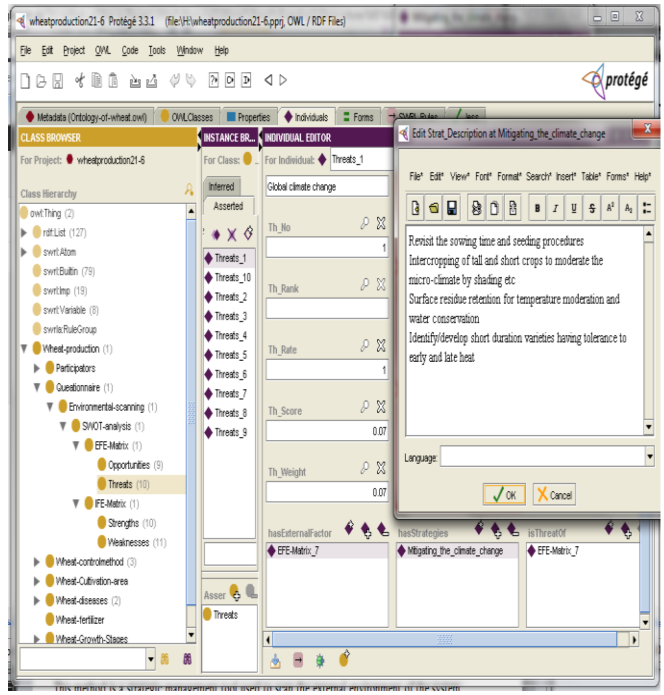

Fig. 7: Global Climatic Change threat and the strategy of mitigating it

Figure 5 shows some rules of Wheat ontology, especially rule15 which represents the previous rule.

Furthermore, Figure 6 illustrates the attributes of smut disease. Furthermore, Figure 6 illustrates the attributes of smut disease.

Also issues and strategies are embedded in our ontology as shown in Figure 7. Where threats_1 is actually a Global Climatic Change has a strategy to mitigating the climatic change and explanation of the implemented strategy also is illustrated. The rule-based also encompass some rules related to ontology level one.

And the corresponding rule will be as follows:

IF (Threat is Global Climatic Change)

THEN the strategy is mitigating the climate change

And so on for all 40 events, variables and trends that conform the SWOT analysis matrix.

In this paper, a Wheat knowledge base is established. Furthermore, the ontology reasoning and rules reasoning are integrated. The proposed ontology has given the full expression to domain concepts and their relations, and rules relate properties with each other. Thus, the reasoning system does the reasoning on ontology level and rules level. Queries could be executed using the QueriesTab plug-in.

This work is an essential step towards building Wheat ontology from point of view of specialists in the agriculture sector and the proposed ontology needs additional works to be a general Wheat ontology decision support system.

VI. CONCLUSIONS

In this paper, we have introduced an intelligent decision support system, named Wheat Ontology. This ontology could be developed to encompass everything related to Wheat to build comprehensive Wheat ontology. This ontology could be a good diagnosis system for Wheat diseases and it could provide recommendations to help to reduce as much as possible and to treat with Wheat diseases.

It is believed that organizing information about the Wheat production and diseases can play important role in providing solutions to the problems inherent in the Wheat diseases, and could give suggestions and control methods about each kind of disease.

As we are not specialist in agriculture we find a lot of problems to meet experts and to review studies of domain, but this work could be a role stone to advanced work in Wheat field. This work could be of great importance to Syrian government. Experts in agriculture could use this work to review, provide assistance, and reuse the proposed ontology.

REFERENCES

[1] "SYRIA: 2012 Wheat Production Outlook is Favorable Despite Ongoing Conflict", June 12, 2012, [Online].Available:http://www.pecad.fas.usda.gov/highlights/2012/06/Syria/, [Accessed: Oct. 5, 2012].

[2] A. K. Hagan, P. Mask, R. Gudauskas and D. Collins.," Wheat Diseases and Their Control", Alabama Cooperative Extension Service, Auburn University, Alabama 36849-5612, [Online]. Available: http://www.aces.edu/.[Accessed: Feb. 15, 2013].

[3] H. Abanda, A. Ng'ombe, J. Tah and R. Keivani.," An Ontology-Driven Decision Support System for Land Delivery in Zambia", Expert Systems with Applications, vol. 38, pp. 10896–10905, 2011.

[4] R. Saa, A. Garcia, C. Gomez, J.Carretero and F. Garcis-Carballeria., " An Ontology-Driven Decision Support System for High-Performance and Cost-Optimized Design of Complex Railway Portal Frames", Expert Systems with Applications, vol. 39, pp. 8784–8792, 2012.

[5] J. Giarratano and G. Rily., " Expert Systems- Principles and Programming", 4th ed., PWS Publishing, Boston, MA, USA, 2005.

[6] S. Kendal and M. Creen, "An Introduction to Knowledge Engineering", London: Springer-Verlag Ltd, 2007.

[7] A. Thunkijjanukij.," Ontology Development for Agricultural Research Knowledge Management: A Case Study for Thai Rice", Kasetsart University, Ph.D 2009.

[8] S. Y. Mawardi, M. H. Abdel-Aziz, A. M. Omran and T. A. Mahmoud, "Effects of Environmental scanning and structural analysis systems on Long-Term Strategic Planning: Syrian Wheat Production as a Case Study", ASAT-15 Conference, Cairo, Egypt, May 2013.

[9] A. Cline.," Prioritization Process using Delphi Technique", Carolla Development. Available Source: http://www.carolla.com/wp-delphi.htm, 5th, April, 2012.

[10] B. Mishra, R. Chatrath, D. Mohan, M. S. Saharan, B. S. Tyagi, "DWR Perspective Plan: Vision 2025". Directorate of Wheat Research, Karnal, India, pp. 14-15, 2007.

[11] "Strategies to Reduce the Emerging Wheat Stripe Rust Disease", International Center for Agricultural Research in the Dry Areas, [Online]. Available: http:// www.icarda.org/wheatrust, [Accessed: Apr. 8, 2013].

[12] T. Gruber., " A Translation Approach to Portable Ontology Specifications", Knowledge Acquisition", pp.199-220, 1993.

[13] L. Ceccaroni.," An ontology-Based Environmental Decision-Support System for Management of WasteWater Treatment Plants ", Catalunya University, Spain, Ph.D 2001.

[14] A. Pretorius., "Lexon Visualisation: Visualising Binary Fact Types in Ontology Bases", MSc Thesis, Vrije University Brussel, 2004.

[15] A. Maedche.,"Ontology Learning for the Semantic Web", Norwell, Massachusetts, Kluwer Academic Publishers, 2003.

[16] G. Cheng and Q. Du.," The Design and Implementation of Ontology and Rules Based Knowledge Base for Transportation", The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B2. Beijing 2008.

[17] "SWRLRuleEngineBridgeFAQ", [Online].Available: http://protege.cim3.net/, [Accessed: Feb .15, 2013].