

# Ontology of Crop Pest Control

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## ABSTRACT

Domain ontology of crop pest control consists of hierarchically structured biological and chemical information and concepts on crops, pests, pest control measures and relations among them. Despite vertical relations in hierarchies, the knowledge about crop protection measures leads to horizontal relations between classes biological and chemical objects. There is analogy between class objects in biological classification of crops, pests and pest control measures from one hand and from the other hand class objects and instances of object oriented programming. The developed domain ontology has characteristics of task ontology because it leads to building analytical models, data analysis and solving practical problems. Classification of tasks and applications based on the domain ontology is in the scope of this work, as well.

The main aim of the ontology is the development of intelligent computer based systems intended to satisfy specific informational needs of the professionals and practitioners in agronomy, crop protection, plant medicine, economics and business.

## CCS Concepts

•Computing methodologies→Ontology engineering.

## Keywords

Pest control information; Domain ontology; Framework; Hierarchical structures; Relational database; Object oriented approach.

## 1. INTRODUCTION

Crop pest control in agriculture consists of biological, chemical, physical techniques and measures applied by agricultural specialists that depress the development of crop pest populations. The scientific and expert information in pest control domain is usually heterogeneous and multi-disciplinary – biological, chemical, agrarian and legal.

Domain ontology is formal descriptions of the classes of concepts and the relations among them that illustrate an application area [1]. Assessing the quality of domain ontologies for their suitability to potential applications remains difficult, even though a variety

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of frameworks have been developed [2]. Agriculture as an application area presumes building ontologies including conceptualization of crops and crop products, farms located in geographical regions and soil and climate information, concepts related to crop rotations and cultivation choices available to farmers, agricultural activities as a coherent set of crops [3-6] or only one crop [7-8]. Domain ontology on crop cultivation is considered as static information during plant growing (soil, seed and agricultural machines) while task ontology builds on the point of plant process: soil selection, seed selection, fertilization [9]. Crop pest control is a specific domain of agriculture. The ontology of this domain is characterized with symbolic knowledge representation schemes built by scientific defined concepts and tasks and services based on the ontology [10-13]. AGROVOC, National Classifications and Thesaurus, Semantic Web technologies, OWL, Protégé multi-agent methods and graphical tools are used for building ontology in crop pest control [1, 14, 15 and 16].

This paper aims to present domain ontology of crop pest control and basic tasks regarding information, knowledge services, data modeling and analysis.

## 2. CROP PEST CONTROL ONTOLOGY

General model of crop pest control consists of related datasets on crops, pests and pest control measures (figure 1). Each dataset contains classes of biological or chemical objects. The names of classes and objects can be used to define complex relationships among them. “Damage and disease” present the natural processes in the path „crops -> pests”. “Treatment” of damaged crops includes human control measures and biological enemies of pests usually encouraged by human in order to protect the crops.

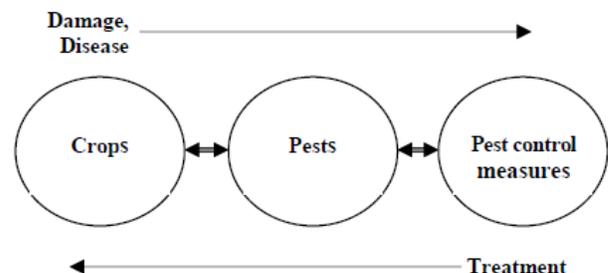


Figure 1. General information model of crop pest control.

Ontological framework of crop pest control is presented on the figure 2. Biological nature and scientific classification (taxonomy) of crops and pests predetermine hierarchical structures that contain class biological and chemical objects. The crops hierarchy is realized based on agronomic purpose of crops. The class of

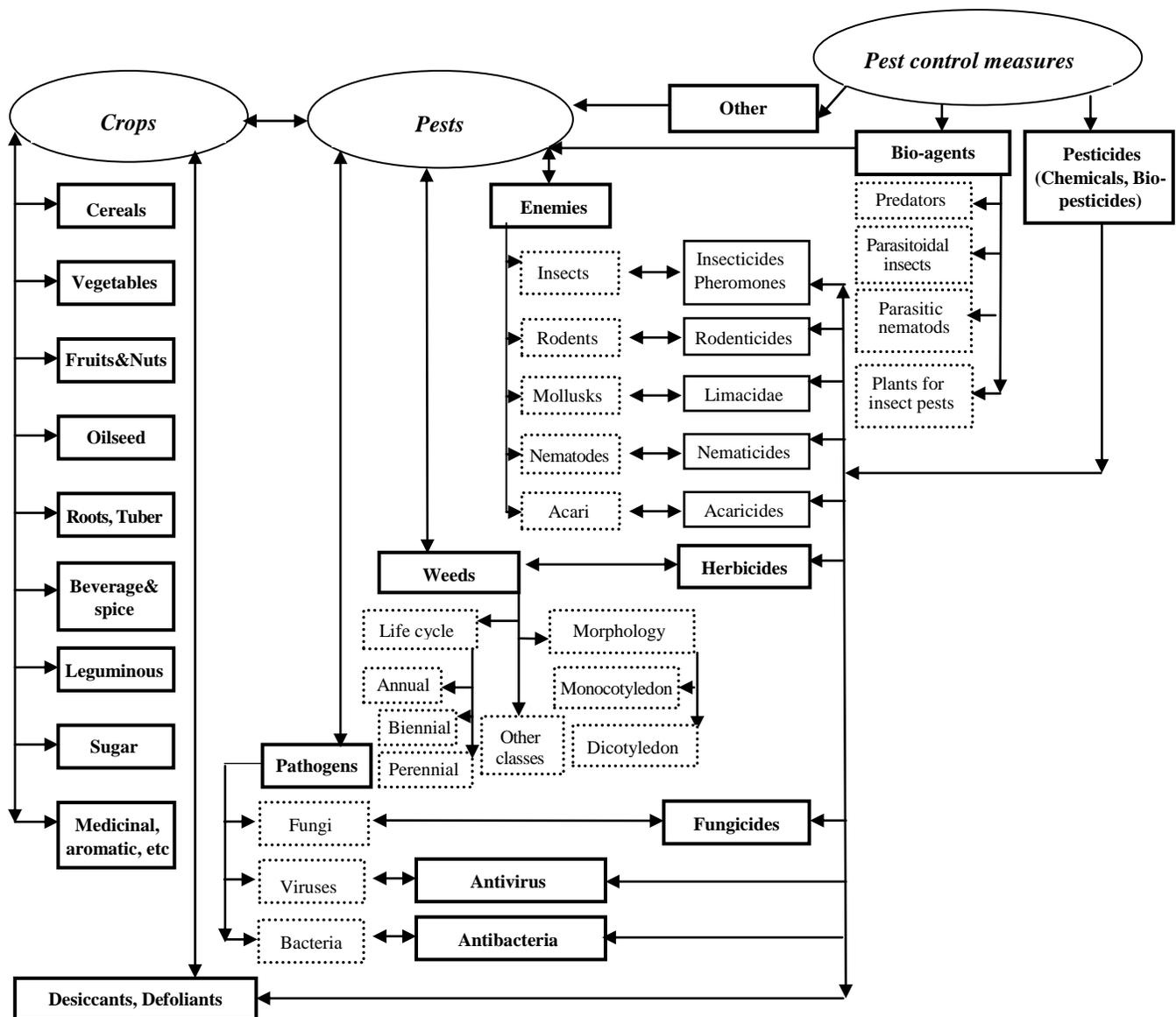


Figure 2. Ontological framework of crop pest control.

pests consists of three hierarchies: Pathogens, Weeds and Enemies. Class Pest control measures covers sub-classes Pesticides (Chemicals and Bio-pesticides), Bio-agents and „Other” measures. Vertical arrows in hierarchies mean relations “class → sub-class → object (s)”. Despite vertical relations in hierarchies, the knowledge about crops pest control leads to horizontal relations between biological and chemical classes, sub-classes and objects. Horizontal relations here have the following meanings: diseases of crops caused by pathogens, negative influence of weeds and enemies and pest control measures (treatments) by pesticides, bio-agents and other practices. The real existing relations are in both directions: “crops → pests → pest control measures” and “pest control measures → pests → crops”. There is a strong correlation between sub-classes and entities of pests (fungi, viruses, insects etc) and pesticides (fungicides, antivirus, insecticides etc). Each entity in the figure 2 contains a list of items. Let’s have 3 examples: a) cereal crops: rice, wheat, barley, oats, and rye; b) insects: *Myzodes persicae*, *Tribolium castaneum*, Thrips and

many others; c) insecticides: Carate Zeon, Confidor, etc. “Other” pest control measures include information on practices in agriculture, host plant resistance, technologies to introduction or encouragement of antagonistic organisms. Such kind of information is usually presented in easy accessible form, for example text documents in PDF. Concepts from Multilingual Thesaurus AGROVOC are used in building the ontology.

Presented crop pest control ontology is typical domain ontology. It has features of task ontology because it provides knowledge and information needed for task definition and problem solving in the domain. This ontology aims at creating intelligent computer based systems to meet the users’ requirements for knowledge, information and data analysis. Relational approach is proper solution to store semantically related biological and chemical data in easy accessible and retrievable database. The fundamental concepts of Object oriented approach fully correspond to the ontology of crop pest control giving opportunity for data modeling and analysis.

### 3. RESULTS AND DISCUSSION

This chapter goes through domain ontology issues to task ontological issues. Task oriented capabilities of crop pest control ontology provides information and knowledge services based on the contemporary information methods and technologies. Tasks classification is done as follows:

- Creating and exploring relational database and software. Strong points of the relational software are managing the relationships between objects, querying and visualization of related data in the path “crops → pests → pest control measures” and back. Information services are oriented to wide range of users: agronomists and farmers responsible for crop protection measures, students, administrators, people working in pesticides business;
- Data modeling and analysis is required by scientists and experts in biology, chemistry, plant medicine and agriculture working in governmental, scientific and educational organizations. The core of object oriented modeling and analysis consists of managing classes of objects and relations among them. The analogy between classes and subclasses in biology and chemistry and class objects and instances of object oriented approach is a base for flexible data modeling. The object oriented models can be developed through using the classes of crops, pests, pesticides (chemicals and natural products) and bio-agents. In many cases data querying in relational database is not enough, because of the need for more deep data analysis. This descends from close properties of the objects from definite class, but also from variations of the objects in the definite class and variations among classes. Object oriented models and software can be developed for making data analysis. As well, object oriented approach provides instance level modeling that allows working with real names of cultivated crops, pests, pesticides and other terms from the domain. The experts would be triggered by the real data analysis in order to research and develop more effective measures for crop protection as well as to improve the governmental rules, regulations and control mechanisms.
- Building intelligent computer based systems (Decision support systems, Multi-dimensional databases, Platforms etc.) through integration of information, knowledge and software.

Integration of pest control information with spatial data on climate and soil, temporal data on pesticides used for previous time period and agro technical information would be useful. Managers of pest control business will benefit from applying economic models such as control of inventories, cost-benefit models and risk assessment. In this sense the integration of economic models and pest control models is needed. Linking of software systems in agribusiness organization with analytical knowledge from the domain of pest control will support business functions, strategies and decision making processes.

Important role of crop pest control ontology is to convert the unstructured or semi-structured data into structured one – relational database. Bulgarian “Phytopharmacy” database is built using ideas of the presented domain ontology (figure 2). Coding system is applied in the creation of database model to define semantic relations among sets of identified text objects: names of crops, pests and pesticides [17]. Reference book presenting the information on permitted pesticides in semi-structured form is used for building “Phytopharmacy” database. This database stores detailed data on pesticides use: product, manufacturer, active ingredient, dose, minimum lethal dose (MIN\_LD), guarantee period (PHI days), use category and application (figure 3). Agronomists and farmers can easily explore information in the path “crops → pests → pesticides” while specialists in plant medicine usually follow the path “pesticides → pest → crops”. Bulgarian “Phytopharmacy” database manages data on 137 cultures, 273 pests and 741 pesticides. This database does not include bio-pesticides and bio-agents.

Other database applications on registered pesticides for crop protection can be found in Internet sites of the European and Mediterranean Plant Protection Organization and Pesticide Action Network, North America.

Example of object oriented modeling and analysis of Bulgarian “Phytopharmacy” database is presented in [12]. Combined use of pesticides is important because of pest resistance and lowering the costs. Regarding this issue, flexible analytical model is developed for joint resolving two or more tasks for data processing on combined use of several pesticides against identified pests for

Phytopharmacy							
Pest_Groups							
Fungi&Viruses&Bacteria							
Pests				Picture			
Peronospora tabacina							
Product, Manufacturer	Active ingredient	Dose	MIN_L	PHI days	Use cat	Application	
Acrobat MZ BASF Agro B.V.	90g/kg dimethomorph + 600 g/kg mancozeb	0.2%	1750	14	3	10-14 days. PP 40-80 l/decare	
ANTRACOL 70WG, Bayer CropScience	700 g/kg propineb	0,20%	5000	7	1	7-10 days	
VERITA WG Bayer CropScience	44 g/kg fenamidom + 667 g/kg alumine fosetil	0.15%	2028	30	3	7-10 days	
DITAN M-45 WP Indofil Industries Limited	800 g/kg mancozeb	0.2 %	5000	20	3	7-10 days. PP 30-60 l/decare	
CURZATE M DF DuPont IO	4% cymoxanil + 40% mancozeb	0.3%	2000	20	3	7-10 days. PP 30-100 l/decare	

Figure 3. “Phytopharmacy” database: access and visualization of information.

selected crops. The developed object oriented software includes procedures for basic set operations – union and intersection. As well as, the data processing provides variations regarding the different pesticides use. Following the relations between classes of the ontology (figure 2) the developed object oriented software strongly facilitates the sequence of operations in practice: information extraction, modeling, analysis and finally decision support. The next step of data modeling and analysis pays respect to miscibility of the pesticides. It is logical to incorporate or link the expert information on pesticides miscibility to Bulgarian “Phytopharmacy” database. Then the analytical software can be improved to provide completed information services regarding combined pesticide use.

Expert information and knowledge on tobacco production is multi-aspect, heterogeneous, semi-structured and stored in different information sources. Multidimensional database “Tobacco\_BG” integrates expert information on tobacco in Bulgaria, an important crop for the country [18]. This database stores information in four dimensions:

- Phytopharmacy – pests and permitted for use pesticides for tobacco under rules and regulations in the country;
- Varieties – tobacco groups and varieties including description of their special characteristics: genealogy, botanical and morphological features, soil and climate requirements; conditions for production: plant population, breaking, picking, curing etc.; chemical composition of tobacco and tobacco smoke: nicotine, tar, total nitrogen, etc. (figure 4);
- Statistics – statistical time series on harvested areas and quantity of production;
- Legislation – laws and normative documents on tobacco production in PDF form.

The database “Tobacco\_BG” is a systematic solution with high operability that facilitates flexible data access, visualization, querying and updating. It abstracts information classification, substantial relations among entities as well as spatial and temporal details in datasets. This application is an intelligent system which provides integrated information on one crop including concepts of pest control ontology. Multidimensional database “Tobacco\_BG” is an open type solution regarding the number of dimensions giving opportunity to be used as a platform for building databases on diverse crops in Bulgaria and other countries.

Характеристики на сортовете // Varieties characteristics	
Специални характеристики / Special characteristics	
Условия на производство / Conditions for production	
Химичен състав на тютюна и тютюневия дим / Chemical composition of tobacco and smoke	
Показател // Indicator	Описание // Description
Никотин (тютюн) // Nicotine (tobacco)	от 0,62 до 1,1%
Разтворими въглеhidрати // Soluble carbohydrates	от 6,5, до 22%
Общ азот // Total nitrogen	от 1,5 до 2,5%
Катрани // Tar	от 31,7 до 34,3 mg/cig.
Никотин(дим) // Nicotine (smoke)	от 0,50 до 0,87 mg/cig.

Figure 4. Tobacco groups and varieties in “Tobacco\_BG” database.

## 4. CONCLUSION

Crop pest control ontology is developed taking into consideration the significance and complexity of pest control in agriculture. This domain ontology could be determined also as “task ontology” because it provides information and knowledge needed for task definition and problem solving. Classification of tasks based on ontology is done. Applications of the ontology give opportunities to provide knowledge, information and data analysis for experts and scientists in plant medicine and agriculture as well as information services for agronomists, farmers and agribusiness managers. Crop pest control ontology can be useful for application software developers because of systematizing expert information and knowledge from the domain.

Hierarchical structures of crop pest control ontology consisting of classes biological and chemical objects are considered persistent. The list of pesticides is changeable, but the concepts of ontology and data structures in applications remain the same.

Still there is lack of intelligent computer solutions based on pest control ontology. Major routes in the future work could be as follows:

- Databases enrichment. The databases in domain store usually data on chemicals for crop protection against pests. The extension of these databases with information on bio-pesticides and bio-agents would be right decision. This is valid for Bulgarian “Phytopharmacy” database;
- Extension of tasks based on crop pest ontology. Tasks regarding pesticides miscibility and evaluation of economic effectiveness are very prospective. Moreover, the climate and environmental changes will lead to ecological regulations requiring new tasks and analytical models on pest control measures;
- Information, knowledge and software integration. Integration or linking of software systems in agribusiness organization with information and knowledge from pest control domain will support decision making processes.

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