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Research Article

ONTOLOGY BASED EXPERT SYSTEM FOR PESTS AND DISEASE MANAGEMENT OF COTTON CROP IN INDIA

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A B S T R A C T

The challenge in the agricultural domain is how to use the has the power of Information Communication and Technology to build an advisory system which farmers can used to improved the farming exercises hence increase cotton crop production. A large quantity of agricultural information such as soil health information, different cropping pattern, crop disease at specific location and different pests were retrieved from various types of resource such as satellites remotely located, services and sensor connected in network. Cotton crop advisory system for cotton crop explained in this paper which eliminates the gap among agricultural domain experts and cotton crop farmers. The system has mainly three main components: Cotton crop pest Ontology, the web services to communicate between components .We have created ontology which contains information related to soil, crop, disease, pest, cultivation process and other relevant information .We have used Protégé tool for developing this ontology development .The web services were developed for interacting with various sources of data. The Java programming language supports RESTful web services. We have used Eclipse EE IDE and JAX-RS/Jersey API for building RESTful web services. A user interface is provided to Cotton crop farmers to submit their query regarding pest, observed symptoms, disease for cotton crop. Our system generates relevant recommendation of pesticide, insecticide which needs to be used for prevention of disease to cotton crop.

INTRODUCTION

In year 1994 the internet was opened to the general user and thee era of information and communication technology has played vital role which allow as the user to access the information from the World Wide Web. The current search engines such as Google, AltaVista are searching information based on keywords. The keyword based search engine does not allow user to access relevant information very easily. Due to utilization of Semantic web technologies the user able to retrieve relevant information very easily. 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 [1]. Semantic web gives importance to web page contents of web page which allows computers or device which can recognize contents of information web pages as individual can understand .It responds to the user request based on the meaning of the query. Semantic web purpose is converting the data which is unstructured or semi structured into data for the web [3], [20]. Ontology organizes the information in a semantic web with structured framework.

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The ontology can be used for representing knowledge of particular domain.

The ontology is shared dictionary which depicts the individual, domain concepts, properties of individual, and relationship between concepts. The agricultural knowledge base can be created with the help of ontology.

Unfortunately, knowledge base for the plant and crop production is not updated regularly as well as it is not correctly utilized by farmers. Currently the research efforts are made for developing ontology with two methods which are automatic and semi automatic. The cotton crop pest ontology which developed by us is going to be used by farmers to submit their query related to cotton farming. The ontology able to answer any difficult query generated by farmers and it provide relevant solution to farmers.

Research Motivation

Agricultural has an important role in Indian Economy. About 70% population who lives in rural is doing agricultural activities.

Nowadays there is a huge quantity of data about agricultural domain such data about weather, health status of soil,

cropping pattern for different crop, disease affecting to crop which are location dependent, and information about various are retrieved from various types of resources such as web services,netwok sensors, satellite which are located remotely. The collected data are not utilized efficiently and optimally by the farmers due to absence of medium which can flow the data between experts and farmers.

In the agriculture area, the farmers have mostly queries of varieties of crop, soil information, climate condition for crop, cultivation techniques, disease and pest affecting crop. The agricultural expert responds to queries of farmers. Farmers express their queries in natural language. The farmers may not able to understand answer fully Because of absence of time, separation and access it is not feasible for the experts to present physically to respond each query for every farmer. As the expert is not available physically the farmers may not able to understand the expert's opinions or suggestions as a response of query.

In such scenario there is need for an expert system which can make communication between experts and farmers. We are encouraged to build up an expert system in which farmers will be able to can communicate their questions in regional language and response of an experts communicate to farmers.

Related Work

During literature survey, we found existing Agro Advisory systems like eSagu [5], Agrisnet [4], Kissan Kerala [9], aAqua [10], mKrishi [12], lIT Mumbai's Agro Advisory System [13] and Krishimantra [3-5].

eSagu is web based recommended system for agro domain. It uses web technology to resolve the problems of agriculture. The eSagu project initiated in Telangana city of Andhra Pradesh state. In Telugu local language the meaning of eSagu is cultivation. It takes advantage of the inventions of new technology in computer era to construct agricultural information broadcasting system to spread the expert's knowledge or expertise to the farmers which leads to increase crop production. This advisory system developed by Media Labs Asia. It advice to the farmers for improving farm productivity. In this advisory system the farmer can send the status of their crop by sending text or photographs. Based on status of crop Agricultural experts give advice farmers.

The AGRISNET project was conceptualized with the vision of creating interconnected Technology enabled network which can deliver informational services effectively to the farming community. The project aimed to integrate cross functional processes of agriculture, so as to effectively and efficiently communicate informational services to the farming community through one-stop. The access of portal which is web based gives various kinds of information like Soil Health Card, Weather, seed, plant protection, fertilizer to the farmers. Through AGRISNET, the benefits of personalized / individual farm level advice are analyzed to be the most viable alternative to reduce yield gap, increase production and income of the farmer.

Karshaka Information Systems Services and Networking (KISSAN) is an integrated, multi-modal delivery of agricultural information system, which provides several dynamic and useful information and advisory services for the farming community across Kerala. It is one of the leading citizen centric e-governance projects of the Department of Agriculture, Govt. of Kerala. The project was conceived, developed and managed by the Indian Institute of Information Technology and Management- Kerala for the Department of Agriculture, Govt. of Kerala. The key feature of KISSAN is the integrated service delivery model that makes available to the experts from any agriculture related organization to reach timely and effective assistance to farmers anywhere in the state.

The discussion forum AQUA which is designed by IIT Mumbai. The user can use web browser to access the system. The primary goal to create platform to farmers where they can express their problems related to agriculture to experts. It is multimedia and multilingual question, and answer based forum. First user has to register and then he/she can post their agricultural domain queries. and expert will respond to farmers query.

TCS group has developed mKrishi system which is mobile based advisory system which provides audio-video facilities to post their queries. In this system the farmers can send the picture of crop by using their camera of mobile phones. The farmers can also record their questions and send to the system. mKrishi system collects data regarding climate information from nearby weather stations. The soil and crop data are provided by the sensors. After making analysis of all the information the system provides the advice to farmers on their mobile phone.

IIT Mumbai has developed recommended system which uses knowledge base in the form of ontology. This system used by farmers to post their queries to get the relevant solutions for their problem. Ontology is collection of several concepts such as soil and weather condition of cotton crop, cotton crop varieties, disease distressing cotton and insecticide and pesticide to be used for cure of disease. The farming practices data of last five years are accumulated in the relational database for different places of Punjab. This agro advisory system is providing user interface where user can send query to experts. Experts give answer by using ontologies. The ontology is constructed by using Web Ontology Language (OWL) [19].

Krishimantra is recommended system developed for Gujarat state. The information for system is collected using various data sources such as Geographical Information system data, SQL data, and Resource description framework knowledge base. In this system RESTful services are developed to make communication between the system components. The system provides information to farmers concerning farms, farmers, climate information etc. The system recommends pesticide to farmers for prevention of pest and disease. The system can be accessed using user friendly interface which requires minimal training to use the system.

Research Challenge

To develop an advisory system for an agricultural domain is challenging task. We found several research challenges to develop our system.

User Interface: To build user interface for farmers to express their query is challenging issue. The system should be more easy to use to farmers. The users will not prefer to use the system especially farmers if it is complex for submitting their crop related query.

Development of Advisory system based on Ontology: System should consist of knowledge base data. The knowledge base of the system should support semantic searches. Ontology is knowledge representation techniques which supports semantic technologies. Such a knowledge base facilitates us to present improved responses derived from inference and reasoning ability on ontology. The main job is to construct web ontology which can answers queries of each farmers.

Ontology development for cotton crop: - At present we don't have knowledge base of cotton crop pest ontology which has all information for cotton crop cultivation practices. .A full ontology for cotton crop should be constructed which allows farmers to submit any question related to cotton crop farming.

Ontology Reasoning: It is challenging issue to answer the query for user for which the information is not available in knowledge base statically. All the information in the knowledge base is not explicit. The system should have capability to infer the knowledge from existing knowledge base. Ontology reasoner should generate recommendation to farmers after reasoning process.

Natural language queries: The farmers express their query in natural language. A natural language query contains normal terms which used in local language by users. It does not have any specific syntax or format to express their query .The system should allow the user to enter their query in any form, including a statement, a question, or a simple list of keywords. The response of the system should be independent of the mechanism which user has preferred to submit their query.

User interface based on Regional Language: Indian country has much regional language. Mostly farmer knows only regional language. The user interface should supports regional language of state in which farmer is using the advisory system. It should provide the support for submitting the farmer's query and answer generated by system in regional language only. Due to development of user interface based on regional language the farmers will be able to clearly understand the response generated by system based on their query and farmers will act accordingly.

Deployment of the system: System should be easy to access. The system should be deployed on a cloud which can be effortlessly available to users. Knowledge base, services to retrieve agricultural information and records of agricultural should be placed on cloud such that the user can able to use from anywhere, independent of location.

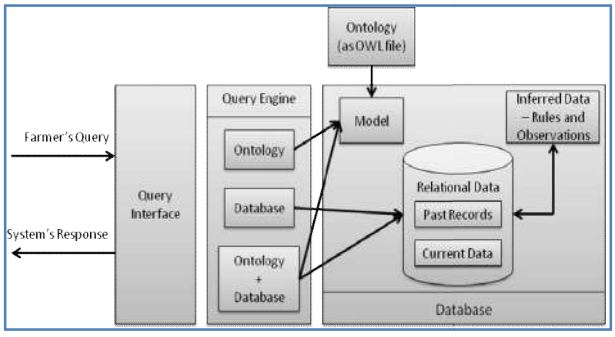

Fig 1 Expert System Architecture

Design and Implementation

Our system will help the farmers by improving the production of cotton. The architecture of our system is shown in Fig-1. The online system is accessible using web browser and mobile device. The farmers can request the information related to surrounding farms, disease, request for recommendation regarding prevention and cure of disease. The farmers will also able to get weather data and also get warning and notification is there are any sudden or adverse changes in the weather condition.

The major components of system explained below.

Structured Query Language (SQL) database: The database contains the information which does not alter regularly. It contains information related to farm and soil. The information which contain in sql database used for handling registration of the farmers and it helps farmers to get relevant information.

The Resource Description Framework (RDF) knowledge base: It contains data for cotton crop in RDF format. It contain information in the form of different concepts such as Pest,Disease,Climate,Insecticide, SPARQL is RDF query language and reasoning are used on cotton crop ontology to respond the query of farmers. We have used protégé tool to construct ontology.The knowledge base for cotton crop is represented in Resource Description Data format (RDF) format. developed ontology using protégé tool [12], is used for representing knowledge in the form of cotton ontology. To query the ontology Apache Jena Framework is used and response of queries is given to farmers using web services.

Database: The database stores the farming practices for cotton crop in the form of ontology and relational database. The ontology information is stored in the form of onto graph. It stores dynamic information such as symptoms of diseases, pest, insecticide and pesticide to be used for cure and prevention of disease. The query and inference engine retrieve the information from ontology and relational database and generated response is communicated to farmers through web services.

RESTful services: The RESTful services are created to make communication between the different components which are present in the system. The services establish connection of user with knowledge base which is in the form of SQL database, the RDF format.[11] The user submit their query with the help of services. The response of the query generated and convey to user using services. The services have REST architecture style. We have used Eclipse Integrated Development Environment for developing services using JAX-RS supported in java programming language.

Graphical User Interface: The system can be accessible by a user using a web browser. The farmers can place their query to system with the help of user friendly user interface. The query post by farmers is in natural language which is parsed, tokenized and mapped to resources in the ontology.

Query Engine: It is one of core component of the system which has the capability to handle query which is raised by farmer. To answer the query the query engine will use the knowledge base of cotton farming practices which is in the form of ontology and database. Currently we are handling ontology-based query. This is taken care by designing an

algorithm which returns a path that best matches cluster of resources selected by user query.

Implementation Detail

We have used the following Domain specific knowledge materials and tools for development, testing and deployment:

Domain specific knowledge materials

1. Cotton (Kharif) Crop production and related subject textbooks.
2. Farmers data (past records & current data)–As relational database
3. General ontology construction guideline (agropedia.iitk.ac.in/km_guidelines.pdf) (http://www.coode.org/resources/tutorials/ProtegeOWLTutorial-p4.0.pdf)
4. Related relationship schemes.
5. Cotton Information Hub(http://www.kapasindia.com/)

Tools and Applications

1. Protégé-OWL ontology editor and knowledge-base framework.
2. Cmap Tools version 4.08 COE (http://cmap.ihmc.us/).
3. Oracle 11g database management for Cotton Database.
4. Jena Adapter for Oracle Database
5. Eclipse IDE

Equipments

1. Computers servers
2. Computer for processing

RESTful services developed

We have developed RESTful web services to establish communication between different components of system. Some of web services are explained below.

CottonCropInfo: This service gives information regarding various stages of cotton crop.

CottonTypeInfoService: This service gives information about the cotton crop which need to farm based on the soil information provided by farmer.

CottonVarietyInfoService: The different cotton crop varieties are retrieved from our ontology knowledge base by passing the arguments of query as CottonVarietyId. It will retrieves name of variety of cotton crop such as BT Cotton etc.

CottonPestInfoService: It will return names of the pest which are affecting to cotton crop during various stages.

CottonPesticideInfoService: This service returns the names of the pesticide which needs to use for prevention of the disease which highly affects the cotton crop production.

DistrictInfoService: This service gives names of all districts where the major cultivated crop is cotton. It retrieved information from our database based on passed parameter districtid.

RESULTS

The developed system which can be used by user using computer which have internet access. The system can be accessible using browser. The SQL database and the ontology in the form of RDF (Resource description framework) are stored in the server.

The recommendation to the farmers can be generated using RDF concepts and ontology which helps the users to get all the queries answered promptly and very easily. The system is able to answer the queries related to disease and pest affecting the cotton crop. It also generates the recommendation for the pesticides and insecticides which needs to be used to prevent the relevant disease. The prevention recommendation is generated with considering symptoms, obtaining types of soils and cotton crop variety which is used.

In our system there is a provision for reporting new disease affecting the cotton crop and which can be easily added in our database. The farmers can also take precautionary measures if the crop of nearby farmers gets affected with pests.

System Screenshots

The system is using crop pest ontology as a knowledge base. The constructed crop ontology is shown in Fig.2 The concepts with its name are represented with rectangle. We have used different types of concepts such as Pest, Insecticide, Pesticide, Disease, Cultivation, sowing, Irrigation, Fertilizer, Cropping system, Postharvest Process, Climate etc. We have used protégé tool for constructing ontology. To collect information regarding cotton farming practices we have refereed various resources such as handbook of cotton [13], agropedia [12], and website for Central Institute for Cotton Research (CISR), etc.

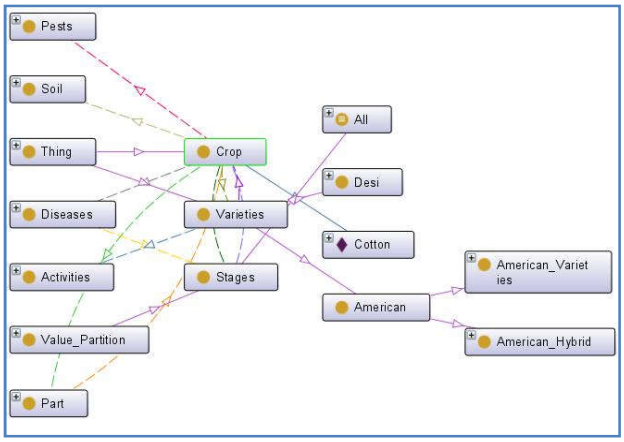

Fig 2 Snapshot of Crop Ontology Concepts

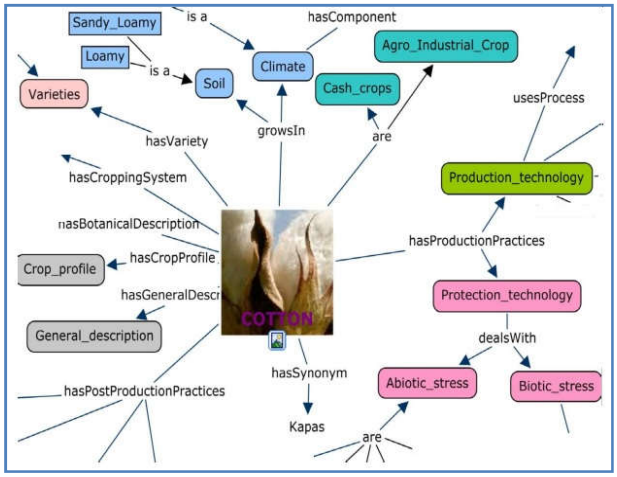

Fig 3 Snapshot of Cotton Ontology Concepts

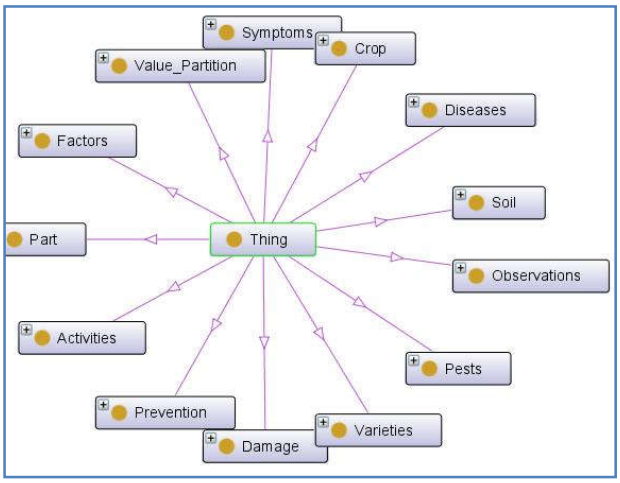

Fig 4 Snapshot of Cotton Ontology Concepts

The cotton ontology shown in Fig 3 and Fig 4.The cotton ontology stores the information about the varieties of cotton crop such as desi cotto,bt cotton etc and different types of soil such as loamy,sandy loamy soil where the farmers can get more yield of cotton. It also stores the information about the climate condition which affects the cotton crop.

There are different kinds of pest affecting cotton crop in India. The dangers of cotton pests in cotton production process have been a more prominent issue, seriously affecting the cotton production. In order to effectively diagnose and control pests we have carried out many different aspects of studies and explorations.

The pest ontology for cotton crop shown in Fig 4.The pest ontology is constructed which contains knowledge base of different types of pests is affecting cotton crop at different stages which are from sowing of seed to maturity of cotton crop. There are The concepts are created for pest such as insect pest, sucking pest, stem_ feeder, strainers, semi loopers which are affecting cotton crop. The regional name and scientific name of all pests were stored in the ontolgy.

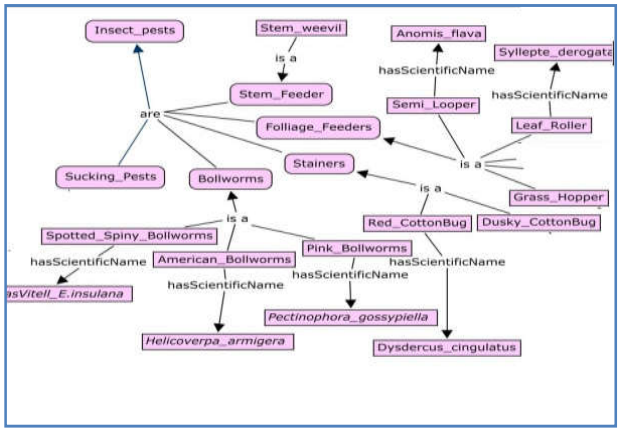

Fig 5 Snapshot of Pest Ontology

There are different types of disease such as bacterial, fungal, viral affects cotton crop. The disease ontology constructed which stores the information about different types of disease, symptoms of disease, and pesticide and insecticide which needs to used to cure and prevention of disease. The disease ontology is shown in Fig.6 and Fig 7. The concepts in disease ontology are connected to other concepts by using more than one relational name. e.g. is_prevent_by is relation name connects disease and prevention concept. Here disease is domain concept and prevention is range concept.

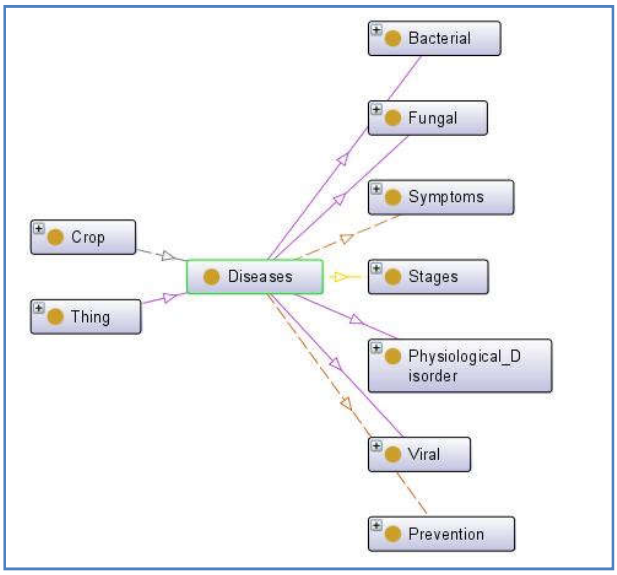

Fig 6 Snapshot of Disease Ontology

Semantic Technologies features support storing, loading and operations on RDF/OWL models. Each model contains a set of subject object relationship triples organized as an RDF/OWL graph of directed labeled edges. The edge is the link (or relationship) that connects a subject node to an object node and is labeled by a predicate [21]. The relationship between concepts is shown in Fig. 8.

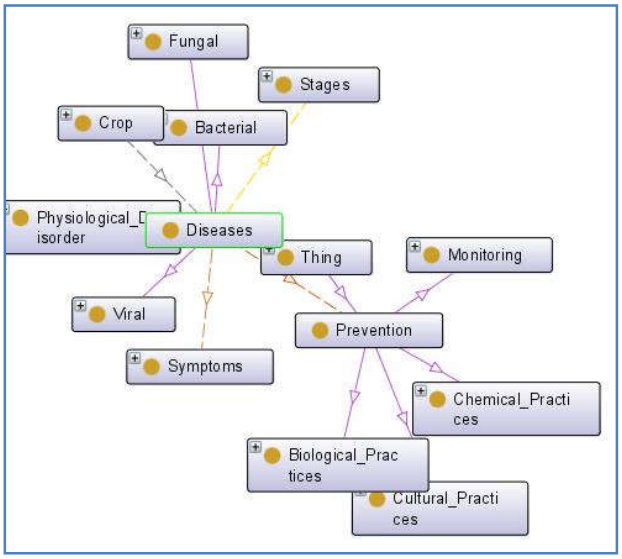

Fig 7 Snapshot of Concept Relation

For direct querying of ontologies, SPARQL can be used. SPARQL is the query language of the Semantic Web. It queries RDF graphs, which consist of various triples expressing binary relations between resources, by specifying a sub graph with certain resources replaced by variables. SPARQL queries were written to fetch the data from knowledge base which is in the form of ontology to respond query of farmers. Few of SPARQL queries are explained below.

Query-1) Advice for disease prevention technique based on observed disease and parts of cotton plant affected by disease. The query retrieves the data from the ontology which is act as an input and the recommendation for disease prevention is the

output generated. Recommendation is generated based on the symptoms and the affected parts of cotton crop. Recommendation consists of pesticide, insecticide, fungicide as a disease prevention practices .The response generated by system for query1 is shown in Fig 9.

Disease	Disease_Prevention_Description
Grey_Mildew	Destroy crop residues
Grey_Mildew	Crop should be rotated with cereals, and preferance should be given to tolerant varieties
Grey_Mildew	Deep ploughing
Grey_Mildew	Dusting by 8-10 kg of sulphur powder effectively control the disease
Grey_Mildew	Foliar application of sulphur at 10 days inteval from the day of first sowing

BUILD SUCCESSUL(Total time :5 seconds)

Fig 8 SPARQL Query result for Query 1

Query 2) Advice for disease prevention technique to be used for cotton plant based on current climate condition. It will retrieve current climate data and recommends disease prevention techniques such as chemical and biological control to prevent the disease. Here the weather data taken as an input and prevention technique is an output. The response generated by system for query1 is shown in Fig 10.

Disease	Disease_Prevention_Description
Bacterial_Blight	Apply B.t.k @1kg/ha
Bacterial_Blight	Plough deeply to expose the purpose and hiberanting rate
Bacterial_Blight	Spray spoodoptera NPV@250 L.E/ha
Bacterial_Blight	Mechanical Collection when larvae are feeding in groups i.e te younger larvae
Bacterial_Blight	set up pheromone traps
Bacterial_Blight	Collection and destruction of egg masses
Bacterial_Blight	Release of predators Chrysoperla carriea @50,000 /ha
Bacterial_Blight	Spraying insecticide endosulfan 35 EC @ 600-750 ml/ha effectively reduce the pollution also

BUILD SUCCESSUL(Total time :4 seconds)

Fig 9 SPARQL Query result for Query 2

Query 3) Advice for the pesticide details to be used for Bollworm pests cotton plant. To get correct pesticide name for prevention of Bollworm pests we have used ontology and reasoner which inference the ontology to generate the desired result. It will generate all the results of pesticide name for bollworm pest. The response generated by system for query1 is shown in Fig 11.

Pesticides
Acephlate
Alphacypremetrthin
Betacyfluthrin
Carbaryl
Detamethrin
Enamecetone_Benzloe
Profenol
Bacterial_Blight
BUILD SUCCESSUL(Total time :4 seconds)

Fig 10 SPARQL Query result for Query 3

CONCLUSION AND FUTURE SCOPE

We have presented paper which introduces recommended system for cotton crop farmers to improve cotton farming practices. It uses advanced semantic web technologies such as ontology, Resource Description Framework, SPARQL query language. Due to the use of SPARQL query and reasoning capability our system to generate recommendation to farmers regarding cotton crop farming practices. The system generate advice such as what is best time for sowing of seed of cotton crop, names of spraying insecticide and pesticide for cure and prevention of disease which lead to increase in production of cotton crop. The system also considers external factors such as location of the farm, presence of any disease in surrounding farm while generating recommendation to farmers.

Our system can be more useful to farmers if we could include current climate condition data and prediction techniques for weather. The system can generate and send alert and notification to farmers so that precautionary steps can be taken in advance before heavy damage occurs to farmer. The system can also be extending to include the soil health condition of farm. After analyzing soil health data the system will generate recommendation such as which is best crop to cultivate, what are best fertilizer to use to increase the productivity? To provide the alert for weather change and recommendation to improve the soil condition more concepts of soil and weather should be included in the ontology which make the scope of ontology large. The system can generate effective recommendation if it has larger ontology and efficient inference engine capability. Mostly the farmers know only regional language. The user interface in regional language can be developed which allows the farmers to present their query to expert.

Many advisory systems were developed to perform search on documents but with the involvement of Ontology into picture very refined way of searching mechanism can be achieved. This work mainly focuses on process of building cotton crop ontology For farmers. Show how much effective the final results of queries are by adding knowledge to such systems in terms of Ontology. And here ontologies play important role to provide schemata or intelligent view over information resources. Therefore, ontologies for Cotton plant production, as the one generated by this study, may be a very useful resource for processing Cotton agricultural knowledge base. Therefore it was a pioneer and pilot work to develop an

ontology prototype for plant production using the Cotton production as a test case study. This prototype will be a model for other agricultural ontology development in the future and through this efficiency of agricultural knowledge management will be improved.

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