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An Artificial Intelligence Technique for Jute Insect Pests Identification

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Abstract – Jute, the "Golden fibre", is a vital cash crop in India and plays an important role in the Indian economy. It provides direct employment and supports the livelihood of millions of rural peoples. By adopting National Jute Policy, the Govt. of India is trying to increase the production and export of jute. But, the present productivity lags far behind the target due to some productivity barriers. Insect pests are one of them. Proper identification of insect pests and their control are vital issues. Identification of insect pests is a primary task and challenging problem for the experts associated with the production of jute. Proper identification of active insect pests needs human expertise, experience and judgment. Considering the total need of human expertise in the domain, they are really a scarce commodity. To mitigate the lack of human expertise, an Artificial Intelligence based consultation expert for insect pests identification might be useful. This work presents an AI based system for insect pests identification in jute.

Keywords: Artificial Intelligence, Expert system, Jute insect pests.

I. INTRODUCTION

Besides cotton, jute (*Corchorus sp.*) is one of the important fibre cash crops to the farmers in India. Jute is called the "Golden Fibre" for its natural lustre. The finest jute is grown on the Indian subcontinent. India is one of the major global exporters of both jute fibre and woven jute products [1].

Jute is a seasonal plantation crop and spread over a large area providing the bread and butter to a large number of people along with the inflow of foreign capita, nearly about Rs. 1000 crores per year. The jute sector plays an important role in the Indian economy in general, and eastern region in particular. The jute industry provides direct employment to about 0.26 million workers and supports the livelihood of around 4.0 million farm families. Around 0.14 million people are engaged in the tertiary sector and allied activities, supporting the jute economy.

By adopting National Jute Policy, 2005; the Govt. of India aimed to increase the annual exports of jute and jute products to nearly Rs. 500 crores. But the present productivity goes far behind the target [2], because the jute sector has been beset with several problems. There are so many productivity barriers, one of them is insect pests. The overall crop loss due to insect pests is believed to be more than 12% of the potential production [3].

Jute is grown in rainy climate; thereby providing a favourable breeding ground for variety of insect pests. Each species produces their own characteristic symptoms of damage. So proper identification of insect pests is highly necessary for taking control measures and ultimately to achieve the target of production.

Proper identification of active insect pests needs human expertise, experience and judgment. Considering the total need of human expertise in the domain, they are really a scare commodity. To mitigate the lack of human expertise, a computer-aided consultation expert for jute insect pest identification might be useful. Several systems have been reported for different crops [4-11], but to the best of our knowledge, no such comprehensive work have been developed. So the aim is to develop an Artificial Intelligence based automated system for insect pest(s) identification in jute.

This work suggests an Artificial Intelligence based automated insect pests identification expert for jute.

In section II, the major insect pests of jute are described. Problems of the domain are discussed in section III. Section IV contains the knowledge management of the system. System architecture and implementation are discussed in section V. Section VI contains the performance evaluation. Finally, conclusions are summarized.

II. MAJOR INSECT PESTS OF JUTE

There is numerous number of insect pests active in jute, out of which six are causing major damage [12]. We have considered that six major insect pests in designing our system, which are Jute stem weevil, Hairy caterpillar, Red mite, Jute semilooper, Yellow mites and Root-knot nematodes.

A. Jute stem-weevil (Apion corchori)

The insect appears on the plant early at seeding stage. There are numerous overlapping generations of insects in the field. The nodal region below leaf base is the spot, most susceptible for damage, whereas the nodal region opposite leaf-base records very low incidence of the pest. The internodes are also attacked but no incidence is found in the leaf lamina, though petioles are at times attacked. The insect exists throughout the entire crop season. The crop, raised either during the month of April or in the first week of May become liable of Apion damage. Adult weevil feeds on tender leaves making pinholes. They attack top shoot for egg laying, making top shoot dry up and as a result side branches develop and reduce the length of fibres. As a result of injury, mucilaginous and gummy substances are produced in the stem and it produces knot on the fibre. Fibre having knot is called knotty fibre.

B. Hairy caterpillar (Diacrisia obliqua)

This pest also causes serious damage to jute. It is most prevalent in heavy rainfall areas like Assam, North Bengal and Tripura. They eat almost all the leaves including growing points. Only the caterpillars are harmful to the jute crop. The young gregarious caterpillars feed gregariously on chlorophyll tissues from lower surface of same leaf giving a peculiar membranous appearance. Then they attack another leaf. They scrape the green part of leaves, leaving only the midribs and cross veins.

C. Red mite (Oligonychus coffeae)

The mite is polyphagous, hence its distribution is widespread. Its incidence is of sporadic nature but occasionally it causes serious damage to the crop. The leaves affected by continuous feeding by adults and nymphs become leathery, turn yellow and drop off prematurely. The incidence of the mite is very much dependent on weather factors, viz intermitted shower followed by dry spell with high humidity are quite favourable. Crop sown during March and April are likely to be more affected because during the following two months, conditions are generally conducive for multiplication of the mite.

D. Jute semilooper (Anomis sabulifera)

The pest appears on the crop usually from the last week of June to the first week of July. Eggs are laid on both surfaces of leaf, preferably the lower side. Three to four broods are reported during a season but the second brood larvae cause severe damage during the period from early July to mid-August. Late-sown crop (due to delayed monsoon) suffers the maximum damage. The larvae just after hatching feed on the epidermal tissue and mesophyll of the lower surface of young leaf, keeping the upper epidermal membrane intact.

E. Yellow mite (Hemitarsonemus latus)

Both adults and nymphs are injurious. They mostly feed on the apical leaves on dorsal side and thus cause curling and crumpling of lamina backwards along the midrib. Owing to the tiny size of the pest, it is hardly seen through naked eyes but the damage is obvious. Early crops sown during March and April are liable to be more infested by mite than the late sown crops. This destructive pest causes terminal leaves to become malformed. The mite's toxic saliva causes twisted, hardened and distorted growth in the terminal of the plant. Mites are usually seen on the newest leaves.

F. Root-knot nematode (Meloidogyne sp)

As a result of their attack, the roots become swollen and uptake of nutrients from soil becomes less. Leaves appear light green and dull in appearance. Early-season infection leads to worse damage. In most crops, nematode damage reduces plant health and growth. Crops grown in warm climates can experience severe losses from root-knot nematodes, the damage results in poor growth, a decline in quality and yield of the crop and reduced resistance to other stresses (e.g. drought, other diseases). A high level of damage can lead to total crop loss. Nematode-damaged roots do not use water and fertilisers as effectively, leading to additional losses for the grower.

III. PROBLEMS OF THE DOMAIN

In recent years, there has been a greater dependence on the use of pesticides with little importance laid on the hazards of chemicals. At present there is a general trend throughout the world to minimize chemical residue in agricultural products. Indiscriminate and excessive use of pesticides create bio-amplification of the residue in human system and consequently invites bio-disorderness in human health. Application of any pesticide against non-target pests may have an adverse effect. The natural parasites and predators of the insect pests may be affected and thus causing resurgence of pests. So, more judicious application of pesticides is required demanding proper expertise.

In jute, the insect pests are being controlled mostly by the use of chemical insecticides and any decision regarding the identification of active insect pests and corresponding control measures are taken by the human experts. The proper identification of insect pests demands adequate expertise and it is not possible to provide such experts to each and every corner of this wide-spread cultivation. So in a large number of cases, improper identifications are the ultimate result. So, proper identification of insect pests is challenging issue.

IV. KNOWLEDGE MANAGEMENT

The system's knowledge had been acquired through three knowledge sources (i) published literatures (ii) human experts (agricultural entomologists) and (iii) cultivators. As the first source of knowledge, various literatures were studied like, books on the subject and workshop reports published by Jute Research Agencies of both India and Bangladesh [3,12].

Secondly, human experts had been consulted through structured interviews. Forms were prepared to record the knowledge extracted from those experts. The experts were requested to give their judgment for different sets of possible observations.

As the third source of knowledge, several field cultivators of jute were consulted to acquire their experience and knowledge. Some physical observations were recorded and incorporated in the system.

The unstructured knowledge as acquired from the above sources were structured and formalized. The knowledge is then represented in object-oriented form for later implementation. The knowledge in the system is stored as group of objects. Each group of object is represented by a class with its attributes. A class defines the general properties and structure of a group of objects; attributes describe the object's important characteristics. The knowledge library class serve as a knowledgebase.

V. SYSTEM ARCHITECTURE

The system is designed to identify the insect pest(s) of jute. The system architecture is shown in figure 1.

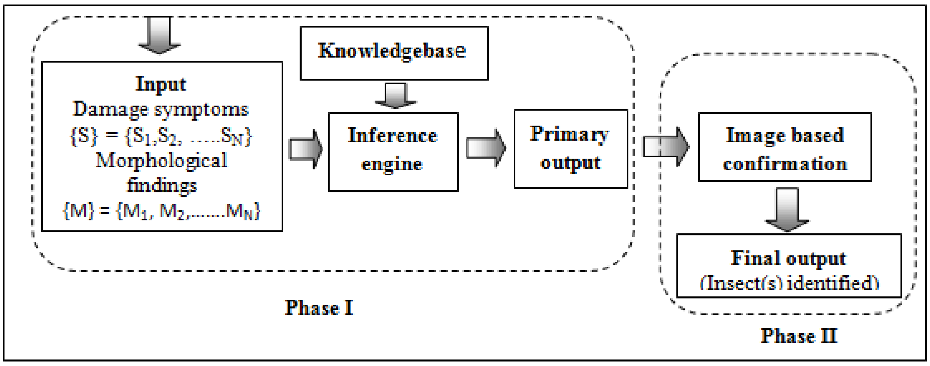

Fig 1. System architecture.

It is a two phase system. The identification of insect pests is done in Phase I and Phase II. During the first phase, preliminary identification of active insect pests in a field can be done on the basis of plant damage symptoms observed in the field. This identification is further confirmed with the knowledge related to the morphological characteristics such as length, body color, body shape, special identity, etc., which the users should have carefully observed during field visits

The system uses domain knowledge in this phase. It asks for inputs related to the damage symptoms caused by insect pests to the different parts of the plants such as buds, leaves, stem etc., and the morphological findings of insect(s).

The production rules of inference are used and a good level of accuracy is achieved in resulting identification. The reasoning is performed by forward chaining with this rule-based knowledge.

'If {S} THEN {P} CF' rules have been used for inferences, where {S} is the plant damage symptoms, {P} is the insect pest(s) and CF is the certainty (confidence) factor associated with the rule.

The certainty factor CF attached to every rule represents the truth membership (confidence) of that rule. The value assigned to CF ranges from 0 to 100. The higher the value of CF, higher is the confidence associated with that consequent. For each rule, the value of CF has been obtained from multiple experts during knowledge acquisition and finally modified based on validation with field data.

The format chosen for definition of rules allows flexibility in structuring the knowledge. An antecedent of any rule may be a composite of a number of clauses or atomic propositions connected via the logical operations AND / OR. An example of decision making rule is:

Rule: stem_weevil_23
IF *((Bush appearance IS Top shoot dry up) AND*
(Bush appearance IS Side branch developed) AND
(Leaf observation IS Spot below leaf base) AND
(Leaf observation IS Pin holes on tender leaves) AND
(Bush observation IS Gummy substances))
THEN *Stem_weevil* CF *97*

As inference propagates from damage symptoms (starting with inputs) to the identification of insect pest(s) (goals), forward chaining of rules had been found suitable [13]. A threshold value (CF = 20) was set for meaningful results as suggested by the experts.

In Phase II, the above inferences are confirmed by displaying the available and possible pictures of the primarily identified insect pest(s) and/or the pictures of the damaged symptoms. After confirmation by the user, CF values is set to 100. In case pictures of insect pests are unavailable, the CF value is fixed to the value that was obtained from phase I.

The system was implemented in an object oriented environment by using LEVEL 5 Object for Microsoft Windows (release 3.0 or higher) by Information Builders Inc, USA. It is an application development tool to combine client/server technology, object-oriented programming, graphical user interfaces and knowledge-based systems. LEVEL 5 Object has an integrated array of powerful tools (GUI development, forms and display builders) and has the capability to chain more than one knowledge base together.

VI. PERFORMANCE EVALUATION

The system has been tasted for two years under real field conditions at the various cultivations of jute in Jalpaiguri Districts, West Bengal, India. For each case, the system's output has been compared with both the expert's judgment and as well as real field observations. It produces results of nearly equally good quality and precision compared to field experts. For better validation of the system, the expert's judgment versus system's recommendations have been recorded for more than 100 real field cases. The agreement is nearly 89 %. Wrong field observations and/or inadequacy of knowledge base might be the reason(s) of incorrect diagnosis.

VII. CONCLUSION

It is a prototype interactive rule-based object-oriented expert system developed to meet up the need of jute industry, at least partially. Suitable GUI components incorporated in the system provide a facility to select and deselect multiple options from a menu. It is a user-friendly system and needs almost no training for its use. Linguistic variable inputs and outputs, which are in natural language and commonly used field terms add advantages to a layman or lesser trained farmer.

Jute is a wide spread industry under different varying conditions. The system should have some region specific adaptability for updation of knowledge base which essentially means that the system leaves scope for further refinement. Our future attempts will be obviously in this direction.

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