

CaneDES: An expert system for disorder diagnosis in sugarcane

Sugarcane crop in India faces many abiotic and biotic stresses which effect the crop growth and thus production and productivity. These stress cause 10-20% loss in cane production and 10-30% loss in cane productivity and may be managed with efficient strategies of crop protection. Institute has taken initiative to adopt Information and Communication Technologies for timely diagnosis of disorders appears in sugarcane crop due to various biotic and abiotic stresses. CaneDES, a web-based expert system for disorder diagnosis in sugarcane crop has been developed to assist farmers in diagnosing disorders occurs in sugarcane crop due to various biotic and abiotic stresses. This work was done under the project entitled “Development of Decision Support Tools in Sugarcane Cultivation” whose PI is Dr S.S. Hasan and Co-I are Dr Rajesh Kumar, Dr S.K. Shukla, Dr Arun Baitha and Dr A.K. Sah. Dr M.R. Singh, Principal Scientist, and Dr Radha Jain, Principal Scientist, IISR, Lucknow contributed in collection of symptoms and visuals of insect-pests, diseases and nutritional deficiencies disorders of sugarcane. Symptoms and visuals were also obtained from secondary literature as well as web site of SBI, Coimbatore and VSI, Pune. We duly acknowledge contribution of all project team members, scientists and organisations who have directly or indirectly contributed in the development of this software.

System uses ontological framework for managing diagnostic knowledge and has been developed using knowledge engineering and software engineering methodologies of developing knowledge-based system. Rule-based diagnostic approach has been applied where rules are consisting of textual and visual symptoms of disorders. To simplify the selection of appropriate symptoms (by user), these has been classified into three different categories viz. Symptom Location (Crop Part), Symptom Attributes and Crop Stage, to ease selection of appropriate symptom for disorder diagnosis.

Symptom Location (Crop Part) refers to classification of symptoms according to crop part where symptom appears. Five types of symptoms have been defined in this viz. Foliage, Stalk, Root, Crop Appearance and Pest Attributes symptoms. Foliage symptoms appears on foliage part of the sugarcane; Stalk symptoms are related with disorder occurs on stalk / stem of sugarcane; Root symptoms are associated with root and soil part of the crop; Crop Appearance deal with overall appearance of crop showing disorder; and Pest Attributes are identification marks of insect-pest and diseases of sugarcane.

Symptom Attributes has been used to classify symptoms according to certain attributes appears in infected sugarcane crop. Eleven attributes has been used to classify symptoms viz. Age / stage related events, Behaviour events, Biting / chewing / infection signs, Coloured variations / object identification, Drying of objects, Position specific events, Quantified event occurred, Unusual shapes of objects, Spots / patterns seen, Strength observed, Touch and smell effects.

Further, symptoms are also classified depending on crop stage. Two stages of crop has been selected in this classification viz. Shoot Stage and Cane Stage and all the symptoms has been grouped in above two stages.

Home page (Figure 1) of the system contains various links related to expert system in sugarcane as well as about Indian Institute of Sugarcane Research, Lucknow. Presently system contains diagnostic knowledge about 40 important insect-pest, disease and nutrient deficiency disorders of sugarcane crop. For diagnosis, it uses 204 textual symptoms and 216 visuals. Diagnosis may be carried out in following manner :

1. **Diagnostic Settings of the System** (Figure 2): This screen permits the settings of various diagnostic options by the user. User can select categories of symptoms under which diagnosis has to be made. Settings can be made for Symptom Categories (Crop Part), Symptom Attributes and Crop Stage. Diagnostic Setting module also allows/disallows display of various symptom categories, visuals and confidence factor for diagnostic screens. Further, user can also provide certain keyword, so that only scrutinised symptoms should be displayed by the system while diagnosis.
2. **Selection of disorder symptoms (textual and visual) along with confidence of symptom selection** (Figure 3). One or more screen are displayed by system (based on diagnostic settings) showing symptoms and / or visuals and / or confidence factor. User can select one or more symptoms along with confidence factor for the disorder appeared in sugarcane crop
3. Based on symptoms and confidence factor provided by the user, it gives one or more possible disorder incidence in the crop (Figure 4).
4. Explanation / Reasoning of diagnosis can be judged using Explanation module as depicted in Figure 5.
5. Further, details of disorder and control methods of selected disorder can be checked in the system by clicking the appropriate button. An example of disorder control methods and disorder details has been shown in figure 6 and 7 respectively.



Figure 1 : Home Page of CaneDES

Diagnostic Settings	
Disorder Category <input checked="" type="checkbox"/> Insect-Pest <input checked="" type="checkbox"/> Disease <input checked="" type="checkbox"/> Nutrient Deficiency	
Symptoms Grouping (Select the Group in which symptoms should be displayed) <input type="radio"/> Crop Part <input checked="" type="radio"/> Symptom Attributes	<input checked="" type="checkbox"/> Sub-Grouping (on Symptom Attributes / Crop Part) <input checked="" type="checkbox"/> Show Visuals <input checked="" type="checkbox"/> Show Confidence Factor
Crop Part (Select Crop Parts for which display symptoms) <ul style="list-style-type: none"> <input type="checkbox"/> Crop appearance <input type="checkbox"/> Foliage symptoms <input type="checkbox"/> Stalk / shoot symptoms <input type="checkbox"/> Root & soil symptoms <input type="checkbox"/> Pest attributes observed 	Symptom Attribute (Select Symptom Attributes for which display symptoms) <ul style="list-style-type: none"> <input type="checkbox"/> Spots / patterns seen <input type="checkbox"/> Biting / chewing / infection signs <input type="checkbox"/> Drying of objects <input type="checkbox"/> Coloured variations / object identification <input type="checkbox"/> Touch and smell effects <input type="checkbox"/> Strength observed <input type="checkbox"/> Behaviour events <input type="checkbox"/> Unusual shapes of objects <input type="checkbox"/> Position specific events <input type="checkbox"/> Quantified event occurred <input type="checkbox"/> Age / stage related events
Crop Stage <input checked="" type="radio"/> Shoot <input type="radio"/> Cane <input type="radio"/> Shoot/Cane <input type="radio"/> All	Symptoms Keyword <input type="text"/>

Figure 2 : Diagnostic Setting of CaneDES

Stalk / shoot symptoms







Sel	Symptoms List	Symptom Visuals	Conf % 10 25 50 75 100
Biting / chewing / infection signs			
<input type="checkbox"/>	Fresh bore holes with presence of wet frass on stalk. Nature and colour of the frass is granular and deep yellow.		● ● ● ● ● ○
<input type="checkbox"/>	Greyish, brown or black, irregularly oval or circular encrustations on internodes.		● ● ● ● ● ○
Coloured variations / object identification			
<input type="checkbox"/>	On splitting cane longitudinally, it shows orange-red vascular bundles in shades of yellow-orange, pink, red and reddish-brown at the nodes.		● ● ● ● ● ○
<input type="checkbox"/>	On splitting cane longitudinally, it shows reddening of internal tissues with white spots on internodes.		● ● ● ● ● ○
<input type="checkbox"/>	On splitting cane, diffused purple or muddy-red colour conical patch at node just above growth ring.		● ● ● ● ● ○
Touch and smell effects			
<input type="checkbox"/>	Stem gets covered with sticky honey dew which serves as a medium for development of black sooty mould.		● ● ● ● ● ○


Figure 3 : Symptoms Query Screen

Expected disorder of your crop			
Select	Disorder Name	Confidence Factor	Selected Symptoms / Total Symptoms
<input type="radio"/>	Internode Borer (पोरी बेघक)	40	4 / 11
<input type="radio"/>	Mealy Bug (मौली बग)	98	4 / 5

Figure 4 : Screen showing Expected Disorder of user crop

Explanation of Mealy Bug (मीली बग) Diagnosis		
Sl No	Symptoms	Visuals
1	Stem gets covered with sticky honey dew which serves as a medium for development of black sooty mould.	
2	Stunted cane growth.	
3	Presence of whitish / pinkish oval insects (mostly immobile) with mealy coating beneath leaf-sheath near the nodes.	
4	Mealy bugs infected stalks can be recognised, after their colonies have dried out, by residues of wax, honey dew & sooty mould, which persist for months.	
5	Mealy bugs attack cane as well as foliage.	

Figure 5 : Explanation about Diagnosis



Sugarcane Crop Disorder Diagnosis

Control Method for Internode Borer

Cultural and Mechanical Control

- Sowing of healthy seed material, de-trashing in 5th, 7th and 9th months and removal of water/late shoots in 8th or 9th months.
- Proper drainage helps in minimising the pest infestation.

Chemical Control

Monochrotophos @750 gm a.i. per ha (36% SL 2 liter/ha) in 800-1000 liters of water spray after removing dry leaves in 4-6 month old crop.

Biological Control

Inundative releases of *Trichogramma chilonis* @ 50,000 adults/ha at 10 days intervals from July to October and a larval parasitoid, *Cotesia flavipes* @ 500 gravid females/ha/week from July to November.

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Figure 6 : Control Methods for Disorder

Sugarcane Crop Disorder Diagnosis

Description of Smut

About Disease

Smut, one of the easily recognized diseases of sugarcane with worldwide distribution, is caused by the *Basidiomycetous* fungus, *Ustilago scitaminea* Sydow. It is present throughout India but its damage is severe in the tropical region, especially in the four southern states of Andhra Pradesh, Maharashtra, Tamil Nadu and Karnataka and Gujarat.

This seed piece transmissible disease has bimodal flush. The first flush (arise due to primary infection) usually appears in May-June, i.e., after the germination of the February-March planted/harvested crop. The second flush appears during October-November, due to secondary infection which takes place during the summer months.

The infected plants produce specific symptoms just before the initiation of whip. Prior to the formation of whip, the infected plants start elongating (outgrowing others). The narrow young leaves with pointed tips come out at an acute angle at the long spaced nodes. But the vivid symptom of smut is the production of a long whip-like black structure from the growing point (apex and side shoot) of the affected cane. The whip is initially covered by a thin silvery membrane of fungal origin and, with passage of time it ruptures exposing the black spore mass. The black spore mass (teliospores), thus exposed, gets disseminated by air current. Although the pathogen produces billions of teliospores per whip, the success rate of infection is very low and it seldom exceeds more than 3 per cent under normal cultivation practices. However, in a highly susceptible variety, if the planting material is fully infected, it may result in a total failure of the crop. Incidence of smut invariably increases in the ratoon crop due to the infection of subterranean buds, which germinates to form the ratoon tillers. Like red rot and wilt this disease is also mainly managed with the use of disease resistant cane genotypes.

Pathotypes
So far two pathotypes have been identified.

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Figure 7 : Description of Disorder