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Expert system for identification and management of abiotic stresses in tobacco (*Nicotiana tabacum*)

H RAVISANKAR[1], K SIVARAJU[2], V KRISHNAMURTHY[3] and C A RAJU[4]

Central Tobacco Research Institute, *Rajahmundry*, *Andhra Pradesh 533 105*

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ABSTRACT

Unlike other crops, tobacco (*Nicotiana tabacum* L.) deserves special mention as the leaf quality is important for its commercial value and export. The leaf is the end-value product and is affected by a number of abiotic factors (both physical and chemical) during the crop growth and curing in addition to biotic ones leading to the economic losses to farmers. Symptoms of the tobacco leaf affected by abiotic factors sometimes resemble biotic factors, misleading in identification of actual causes for taking remedial measures. The information on abiotic factors on tobacco and their symptoms was established and an expert system was developed for identification and management of abiotic stresses in tobacco. The expert system was developed using Visual Basic.Net as front-end application and Oracle as back-end with user-friendly menus. It enables viewer/farmer to identify his problem with different abiotic stress symptoms displayed and identify problem as well as remedial measures.

Key words: Abiotic stresses, Database, Software, Tobacco

Flue-cured tobacco (*Nicotiana tabacum* L.), among the different types of tobacco is an important commercial crop of India. It is grown in an area of 1 80 000 ha in Andhra Pradesh, Karnataka and to some extent in Orissa and Maharashtra producing 260 million kg annually, and about 50% of the production is exported to about 80 countries (Krishnamurthy and Singh 2002). Like any other crop, tobacco also suffers from various biotic and abiotic stresses. Leaf being the end product, it is prone to various abiotic stresses which not only affect the yield but also the quality and usability of the leaf.

Abiotic factors include both chemical and physical factors which will affect various metabolic processes leading to loss of leaf quality. Important abiotic factors affecting the tobacco are weather, water, temperature, chemicals, false maturity, curing etc. Even though, voluminous scientific information is available on various abiotic stresses and their manifestation on tobacco leaf and remedial measures, but it could not reach the end-user at a single place. Manifestation of abiotic stresses on the leaf symptoms is generally misleading, sometimes overlaping with each other and resemble biotic stress symptoms. Expert systems' combine experimental knowledge and experience with intuitive reasoning skills of specialists to aid farmers in making best decisions for their crops (Ravisankar *et al.* 2003, Ravisankar and Murthy 2006, Gonzalez-Andujar *et al.* 2006). In the present study, an expert system was developed which enables user to diagnose the causes of the symptoms on leaf and remedial measures to sustain and overcome the effect of a particular abiotic stress.

MATERIALS AND METHODS

The expert system was developed using Visual Basic. Net (Balena 2005, Gaddis *et al.* 2003) as front-end application and Oracle (Deshpande 2004) as back-end with user-friendly menus. The information collected for designing the knowledge was classified into 4 categories, viz stage, factor, sub-factor and tertiary factor and the object 'Stage' selected as a primary key. The attributes included in the system are Symptoms, Remedial measures, Source, etc. These fields were created with text boxes for data entry/modification and label boxes for title of the text. The user can embed image(s) of a leaf in the knowledge base itself. In the knowledge base, 2 stages are taken and in each stage there are 8 factors stored in the software/database. Each factor is again classified into sub-factors and tertiary factors. Based on the knowledge base, application software has been developed which consists of 14 modules. The multiple document interface (MDI) form of the software consists of 4 options, viz 'Edit details', 'Tobacco Leaf (TL) information', 'Help' and 'Exit'. The 'Edit details' option consists of 3 sub options, namely 'Crop

[1]Senior Scientist (hravisankar@india.com), [2, 4] Principal Scientists (ksivaraju@rediff.com, caraju@rediff.com), [3]Director (krishnamurthy_ctri@yahoo.co.in)

details', 'Stages' and 'Factors'. The 'Crop details' option allows the user to utilize this software for other crops by entering crop details. The 'Stages' option provides an environment to 'add new stage with leaf photo, Edit stage, Delete stage, Save stage' options. For example, if one of the stages is 'Cured leaf', then we can add a new stage as 'Green leaf'. The 'Factors' option displays a new form that allows the user to enter new factors, sub-factors and tertiary factors under each new factor, update or delete the existing factors information. The second option in the main menu namely 'Tobacco Leaf (TL) information' (Fig 1) allows the user to 'Add', Update' or 'Delete' the existing data and 'Generate report' options.

Reports were designed using 'Crystal reports 9.0' by providing flexibility to the user to view selected parameters and take the hard-copy. Interface was provided to the back-end to access the database from 'Oracle' and store the new information into it. The user can view and generate report of the stored data using either 'By Stage and Factor-wise' option or 'By photo-wise' option. According to the selection, the stored information gets displayed with the leaf photo. Click 'Generate report' option to view the same and take the hard copy. If the user clicks on 'By photo-wise' option, leaf photos get displayed on the left side of the screen. If the user clicks on a selected photo, the entire record with an enlarged view of that photo gets displayed (Fig 2).

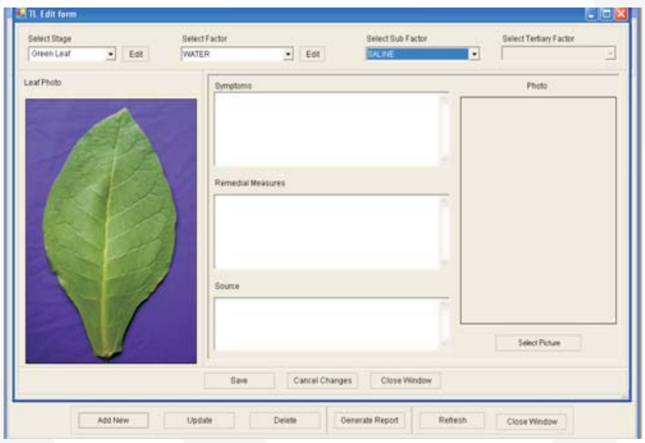

Fig 1 Tobacco Leaf (TL) information

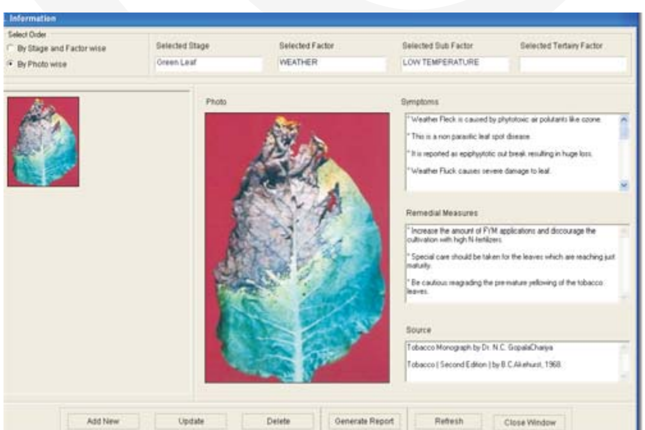

Fig 2 Report Generation

After the coding phase, functional testing was performed on each module of the application software. Integrated testing was done to test expert system. Debugging the system was executed by creating an executable file. The 'inference engine' was designed to accept user input queries and responded to the questions through the I/O interface, and uses this dynamic information together with the static knowledge stored in the knowledge base. The input-output interface was designed which allows user to communicate with the system in a more natural way by permitting use of simple selection menus. For executing this software, a PC with preloaded software of Visual Basic.Net and Oracle is required.

RESULTS AND DISCUSSION

Tobacco leaf, being the value end-product of the plant, is invariably invaded by the several abiotic factors. Weather fleck is a non-parasitic leaf spot caused by the phytotoxic air pollutants like ozone (Heggestad *et al*. 1984). Intensity and severity of fleck is closely related to decreased use of farmyard manure with increased nitrogen fertilization and also low temperatures with high rainfall with poor sunshine during crop growth period. Matured leaves are more susceptible to the fleck than the young leaves and over matured leaves. The spots are seen on the upper surface of matured basal leaves. In the severe case, the spots coalesce affecting the whole leaf and becomes yellow necrotic and collapses (Fig 3). Thus, expert system gives the symptoms of any abiotic stress as above and also remedial measures and the source of information. In this study, the pathway key was developed such that before going to identify weather fleck, it has to be confirmed that the symptoms are not related to the nutrient deficiencies or diseases (Fig. 4).

False maturity is one of the physiological disorders where

Green leaf Weather fleck affected leaf

Fig 3 Weather fleck affected leaf

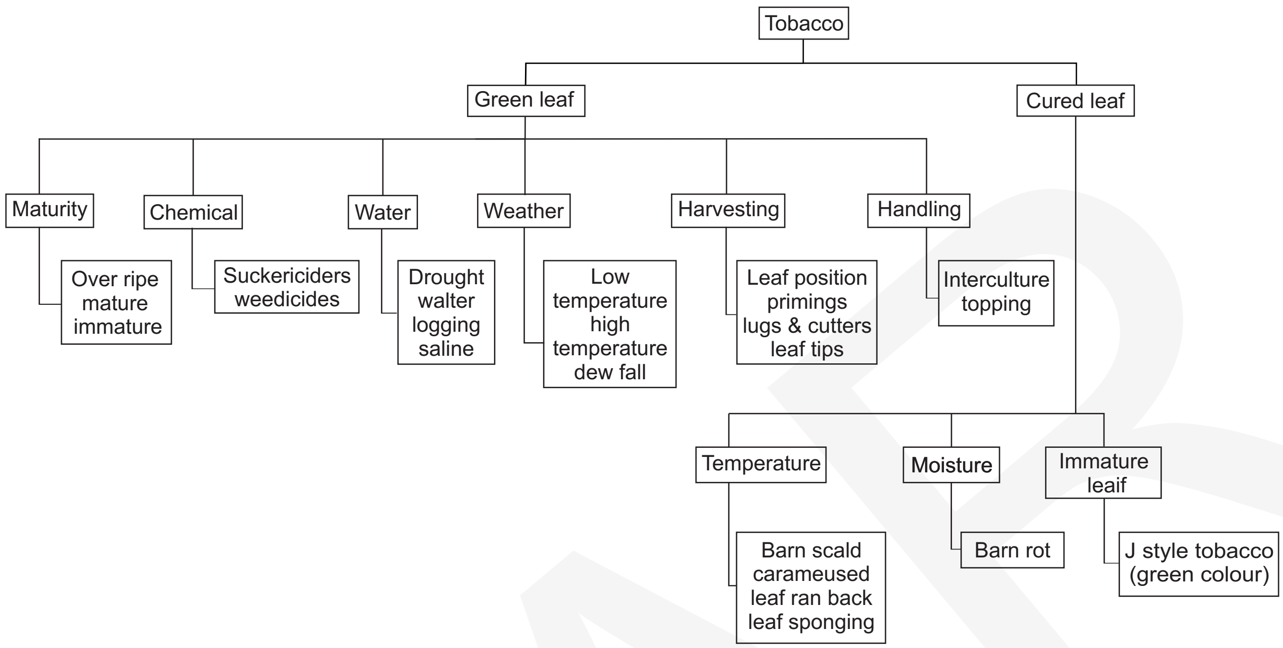

Fig 4 Pathway key for identification and remedial measures of aboitic factors in FCV tobacco

the middle and lower leaves turn yellow and appear as ripened. False maturity may be due to lower levels of nitrogen and moisture in the soil and sometimes due to inundation. False maturity symptoms are different from the symptoms of nitrogen deficiency where the plants are short, slender, light green and lower leaves are yellow. False maturity can be corrected by giving required quantity of irrigation and nitrogen fertilization.

Frenching is usually classified as a physiological disorder. In India, this disorder is observed sporadically in field crop; earliest symptoms consist of chlorosis along the margins, gradually spreading towards the midrib on the young leaves. Frenching can be controlled by adequate use of nitrogen fertilizers with proper soil drainage.

During prolonged dry weather due to lack of required moisture in the soil, tobacco leaves sometimes develop numerous large red-brown spots between veins. Each spot is surrounded by a yellow zone. The spots coalesce to from large irregular patches. The margins of the leaves curve downwards and dry up (Lucas 1975). These symptoms are different from the brown spot affecting leaves where dark-brown or brown spots with yellow rings are seen.

Harvesting matured tobacco leaves is important to get good grades. Tobacco grown on saline soils (chloride content more than 100 ppm) or crop irrigated with water containing more than 50 ppm chloride will contain more chlorides. If the chloride content in the leaf is more than 2%, leaf becomes very brittle in the green stage and on curing produces muddy and uneven colours in cured leaf with excessive hygroscopicity which hampers burn and keeping quality of the leaf (Kameswarao *et al.* 1964). Hence, growing tobacco on saline soils and irrigating with water containing more than 50 ppm chlorides are to be avoided.

Topping is the process of removal of the terminal bud just before or after emergence of flower head. To control the suckers, suckericides are applied on the stem. If the suckericides are applied more than the recommended dose (4%), the leaf bases become very brittle and detached from the stem very easily resulting in loss of green leaf (Nageswara Rao and Palanichamy 2000).

Flue-curing is a curing technique to maintain and enhance the potential quality embodied in the harvested leaf to provide an environment conducive to the transformation of the harvested leaf into a high quality cured tobacco leaf. During the curing, leaf may be affected by faulty curing procedures.

When the leaves are harvested in moist conditions and loaded in the barn, bacterial and fungal infection will occur on either side of the mid vein leading to 'barn rot'. To avoid this, the leaves should not be harvested when they are moist. When the barn is overloaded, due to lack of proper aeration during yellowing stage, light-brown spots form on the leaf, called 'sponging'. Sponging can be avoided by opening ventilators about 7.5 cm.

During midrib drying, if the temperature is increased beyond 160 °F, the leaf tips and margins will be burnt. Such leaf is called as 'caramelised leaf'. Hence, care must be taken so that temperature should not go beyond 160°F. During midrib drying, if for any reason, the temperature falls, the cell sap translocates from midrib to lamina and brown colour appears on either side of the midrib, which later turns to black. This leaf is called 'runback leaf'. So care must be taken during midrib drying so stage that the temperature does not fall below 160°F.

During the colour-fixing stage, the temperature in the barn should be 120°F, if the temperature is raised to more than 120°F, the leaf becomes dark in colour and is called 'barn scald' or dusk. To avoid barn scald, the temperature during leaf drying should not be raised more than 2°F/h. Thus, the leaf affected by the faulty curing methods will cause heavy economic losses to farmers.

This expert system developed for tobacco can be used in any location. The system enables viewer to match his problem with different symptoms displayed and identify problems as well as remedial measures. The present expert system developed is of great use that bring damage caused to tobacco by abiotic factors and their management practices to single stage. Anyone who has basic knowledge of computer operation can easily identify deficiency from the information given by the farmer and can give corrective measures instantaneously. With user-friendly menus, it is easy to execute this system and retrieve information as per the requirements and take the hard copy of the same. The present expert system can also be utilized for other crops because of the uniqueness of the software developed.

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