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CALEX/Peaches, an Expert System for the Diagnosis of Peach and Nectarine Disorders

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An expert decision support system for agricultural management called CALEX is currently being developed. The program runs on any IBM compatible personal computer with 256K or more of memory and either two floppy disk drives or a hard disk and one floppy disk drive.

CALEX initially is being developed for the management of cotton and peaches. The CALEX program is maintained in a modular form so that the domain specific portions can be easily decoupled when the package is extended to other applications. The basic architecture of the CALEX program has been described (Plant, 1989). The CALEX/Peaches program described below contains a diagnostic module for peach and nectarine disorders.

Like most expert systems, CALEX is a rule-based system, so that its knowledge base consists of *production rules* in the form of IF, THEN statements, such as the following:

IF 1. Bud opening is delayed
2. Chilling has been adequate
THEN The disorder is zinc deficiency (certainty = 0.5)

The inference engine pieces together chains of rules in an attempt to reach a conclusion. The statement "certainty = 0.5" represents the numerical "certainty factor" associated with the conclusions. The use of certainty factors permits the program to "reason" with uncertainty. The CALEX rules for combining certainty are similar to those described by Michalski et al. (1985) and are described in detail by Plant (1989).

The knowledge base of the CALEX/Peaches diagnostic system contains ≈600 rules for the diagnosis of 120 disorders of peach and nectarine trees, representing most of their disorders in California. Univ. of California (UC) Extension and California Dept. of Food and Agriculture (CDFA) publications were used to develop the initial list of disorders. This list was reviewed by UC research and extension staff and by the CDFA insect and disease diagnostic laboratories. Additional disorders were included as they were identified by the specialists. Symptoms for the disorders identified were obtained from publications (e.g., Sholberg et al., 1985; Wilson and Ogawa, 1979) and in interviews with UC experts in relevant disciplines.

In CALEX/Peaches, initial subdivision of the rule base is by location (bud, blossom, fruit, leaf, twig, limb, trunk, root, and overall tree) on the plant on which the symptoms are observed. When the user begins a diagnostic session, the expert system first asks for all the locations on which symptoms have been observed. The user may respond with any combination of locations. The expert system then sequentially loads the rule bases for each identified location into memory and processes the rules, continuing until either a definite conclusion is reached or all the locations have been processed.

The expert system continues to process the rule bases until a conclusion is reached with certainty, i.e., with certainty factor equal to one. At this point the conclusion is displayed. The display takes the form of a statement of the diagnosis together with relevant information on its symptoms. At the end of a session, or if no conclusion can be reached with certainty, the expert system displays all conclusions that were reached with certainty >0.25. These are displayed in the order of very likely, reasonably likely, and possible.

Initial validation was attempted by assembling a group of cooperative extension specialists and farm advisors to use the program. A disorder and plant part were suggested, and the individuals then ran the expert system to determine whether the conclusion would match that of their experience. A validation trial was conducted with two groups of graduate students at UC, Davis. A group of nine students was in the plant protection and pest management program, a second one of 12 was in the graduate program in plant pathology.

In Group I, 99% of the identifications were made correctly, while 96% of the identifications in Group II were made correctly (Table 1).

Four of the five incorrect responses by students in Group II involved insects. Subsequent discussions revealed that knowledge of discipline—specific terminology was limiting for the plant pathology students attempting to answer questions about symptoms caused by insect feeding.

The diagnostic module is the only one present in the CALEX/Peaches program. Work is under way to develop other modules; the ultimate goal is for the program to provide complete management decision support for peach growers. Even by itself, however, the diagnostic program is a useful tool. Experienced users have found it particularly useful in aiding in the identification of uncommon disorders.

For information on obtaining copies of the CALEX/Peaches program, write the IPM Implementation Group, Wickson Hall, Univ. of California, Davis, CA 95616.

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Table 1. Student identification of disorders using CALEX/Peaches.

Damage	Plant part	Group 1 Correct[z]	Group 1 Incorrect	Group 2 Correct[z]	Group 2 Incorrect
San Jose scale	Twigs	9	0	10	2
Sunburn and flathead borer	Limbs	9	0	12	0
Brown rot twig blight	Twigs	9	0	12	0
Brown rot	Fruit	9	0	12	0
Peach twig borer	Twigs	8	1	12	0
Bacterial canker	Twigs	9	0	12	0
Zinc deficiency	Leaves and twigs	6[y]	0	11	1
Shothole borer	Limbs	6[y]	0	12	0
Spider mites	Leaves	6[y]	0	10	2

[z]Correct answer was among those identified as possibilities by CALEX/Peaches.
[y]Three students did not complete the exercise.

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