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APPLESCAB A Teaching Aid on Microcomputers

Of the many uses for computers in plant pathology, epidemiologic models offer an exciting challenge for teaching. With a realistic model, students can learn through trial and error, exercising their management abilities without restriction in making decisions; there is no risk of crop loss or environmental damage resulting from a bad decision. An attractive program should be easy to use, self-explanatory, interactive, accessible at any time, and fun. Unfortunately, little has been done to extend this possibility since the introduction of APPLESCAB (1). Most programs run on mainframes (or minicomputers) to which access is often limited and sometimes formidable for pathology students. We present here a microcomputer version of APPLESCAB, enhanced with graphics and self-explanatory at any level.

The Model

The structure of the model has not been changed, and a more detailed description can be found in Arneson et al (1).

The APPLESCAB simulator has four major submodels:

Weather generator. This part supplies weather data to the other parts and offers two possibilities: 1) "canned" weather, which is read from an external weather file and provides reproducible weather patterns, and 2) simulated weather, which is provided by the weather simulator developed by Bruhn (2). In either case, 1-, 2-, and 3-day forecasts are generated with an error factor.

Tree growth. This part provides the growth stages of the trees, total area of the leaves, and leaf area susceptible to apple scab.

Disease development. Disease development is simulated through a time-varying distributed delay with attrition, in an approach similar to the one used by Kranz et al (3).

Fungicide attenuation. This submodel handles the disappearance of fungicide residues on fruit and leaf surfaces owing to fungicide degradation, rainfall, and tree growth.

The Program

Characteristics. The program, originally written in FORTRAN IV, was translated into Pascal, which is currently the most popular structured programming language on microcomputers. The Turbo-Pascal compiler (version 3.0, Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA 95066) was used. This is a very inexpensive and rapid compiler that generates fast, compact code and has become the de facto standard on most personal computers. The graphic windowing was generated with the Turbo Graphix Toolbox (Borland International). The use of overlays allows APPLESCAB to be run with only 256K bytes of RAM (random access memory). The current version runs on the IBM PC, XT (or compatible) with a graphics card (CGC); in addition, the high-resolution mode (640 × 400 pixels) of the Olivetti M24 PC (AT&T 6300) is supported.

Installation. The program comes ready to run. All default values, such as prices and costs, running modus, and names of fungicides and apple varieties, can be changed.

Sample Run

Initialization. The game allows the user to choose the starting conditions, including weather regime, levels of inoculum and of fungicide resistance, and apple cultivar (Fig. 1). The user also selects the frequency of reports on the state of ascospore maturation, i.e., never, weekly, daily, or on request; costs are calculated according to the choice and presented in the final financial report. The daily fungicide cover report can be set to "off" or "on."

Run. On a day-by-day basis, the player can, as in reality, manage the fungicide schedule according to personal knowledge and observations (weather forecast, eventual ascospore report, and fungicide cover). The actual state of the system (tree growth, weather conditions, and disease level) is displayed for each day of simulation; disease progression is graphically displayed from the beginning of the season and updated daily (Fig. 2). Ascospore and fungicide reports are displayed according to the initial choice (Fig. 3), and infection periods, calculated

The APPLESCAB program for personal computers is not copy-protected and will be distributed as shareware. Copies of the program may be requested from the authors. Updates and source may be requested from Ph. Blaise, Institut für Phytomedizin, ETH-Zentrum/LFW, CH-8092, Zurich, Switzerland.

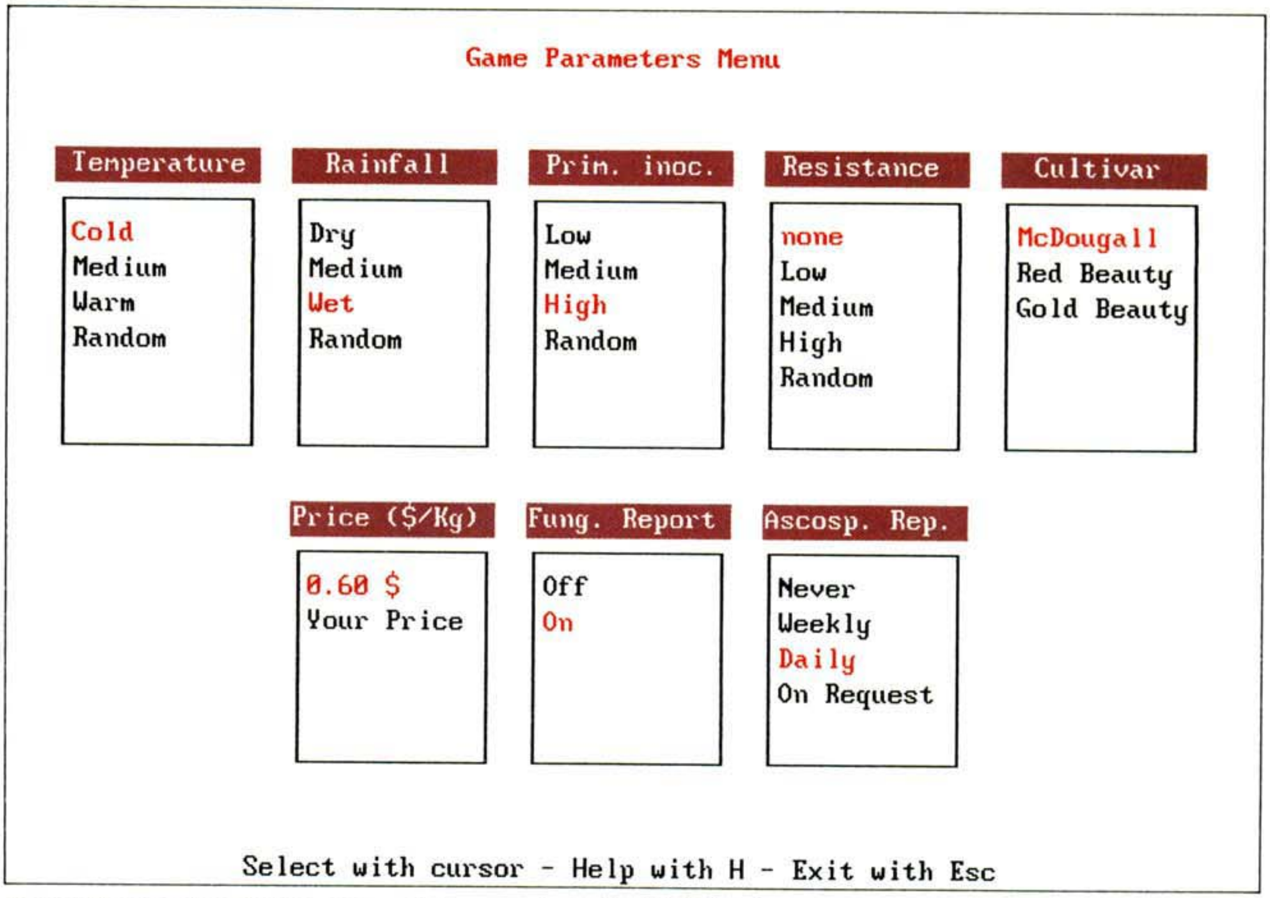

Fig. 1. The parameter selection menu, with the current selection highlighted.

according to the Mills table, are signaled to the user as they occur. At any moment, the user can perform one of four functions: advance a day, advance directly to the end of the season, spray, or (if the option "on request" has been selected) ask for an ascospore report. Help can be requested at any time to get information on fungicides, biology of the pathogen, etc. At the end of the season, the user gets an overview of the weather and scab epidemic (Fig. 4), a report of scab on fruits and the fungicide treatments, and a financial statement (Fig. 5), with which success as a disease manager can be evaluated. Thanks to the incorporated graphics, the player can see not only the actual conditions but also the development of scab up to that point. A decision has to be made daily on whether to advance a day or perform an action. The response to the decision is immediate.

The simulation can be extended over many seasons, in which case the amount of primary inoculum each season is determined by the epidemic of the previous season. The final proportion of the fungal population resistant to systemic fungicides is carried over.

Autoreset modus. In automatic reset modus, the program returns to the beginning if no key has been pressed during a certain period. We have used this feature in exhibitions where people just walk through and, out of curiosity, start a run without finishing it.

Execution time. Depending on the processor used, a daily step requires 0.1–0.4 second to compute and a whole season without intervention (obtained by advancing directly to the end of the season) takes 12–48 seconds (Table 1). The time needed for computation is short enough to allow several runs in a session. Most of the time is needed for decision making, which is unlimited.

Discussion

Models have been and continue to be widely used as training and instruction aids, with an increasing number being run on personal computers (4,6). The disadvantages of most epidemiologic simulation models requiring mainframes (7) are overcome in the version of APPLESCAB described here. Graphic display gives a good overview and allows one to follow the dynamic development of the disease influenced by the interventions. This corresponds to the request made by Zadoks (9) that a dynamic rather than a static approach be taken to decision making.

Residue information, as presented in the game, does not represent the real world, where little or no information is available to the grower. Similarly, ascospore maturity information is available on a weekly basis, at best, in the real world, and assessments of the disease level in the orchard require a considerable effort on the part of the grower unless scouting or management services are used. The described version of APPLESCAB overcomes these inconsistencies by allowing the user to decide

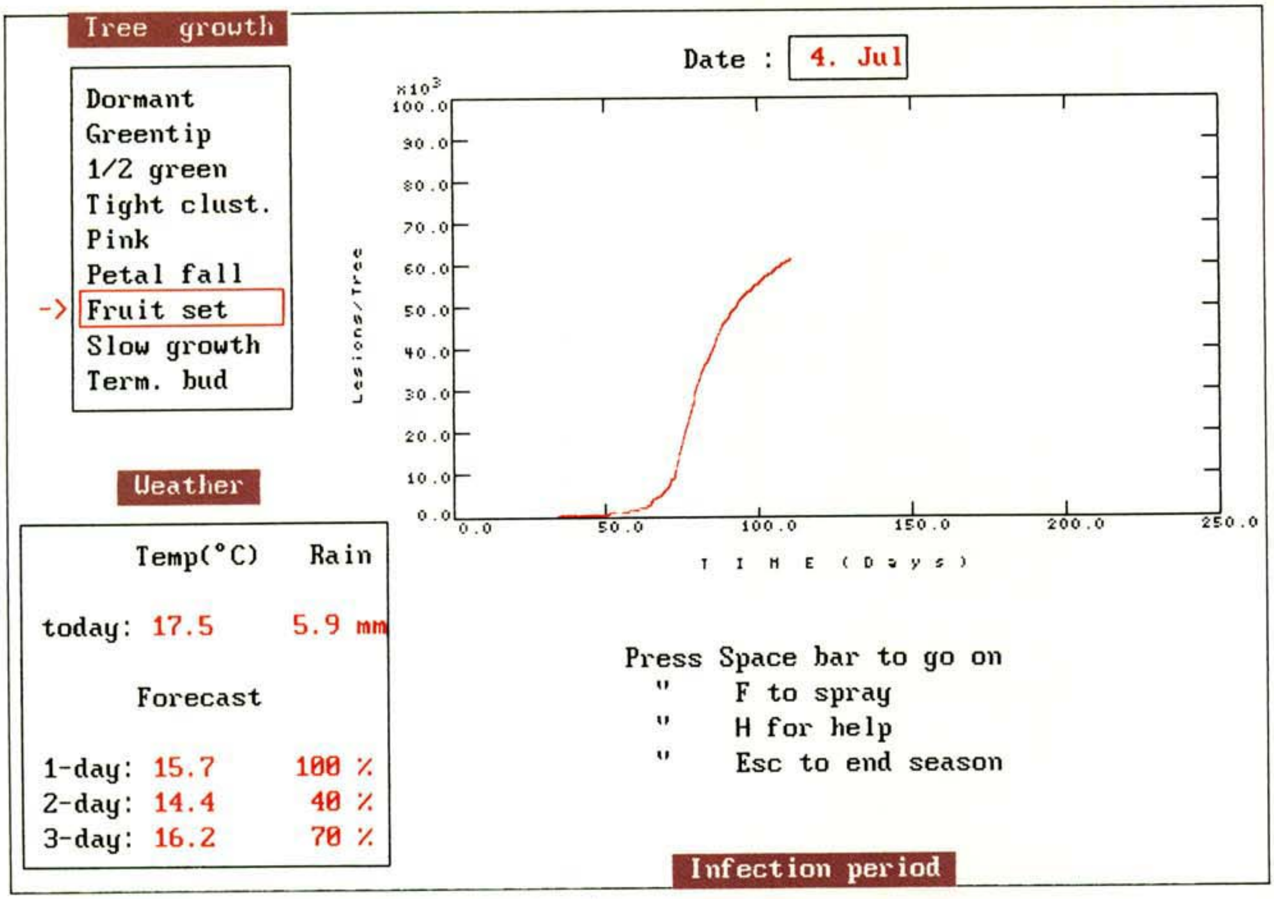

Fig. 2. The display during the game with no report selected.

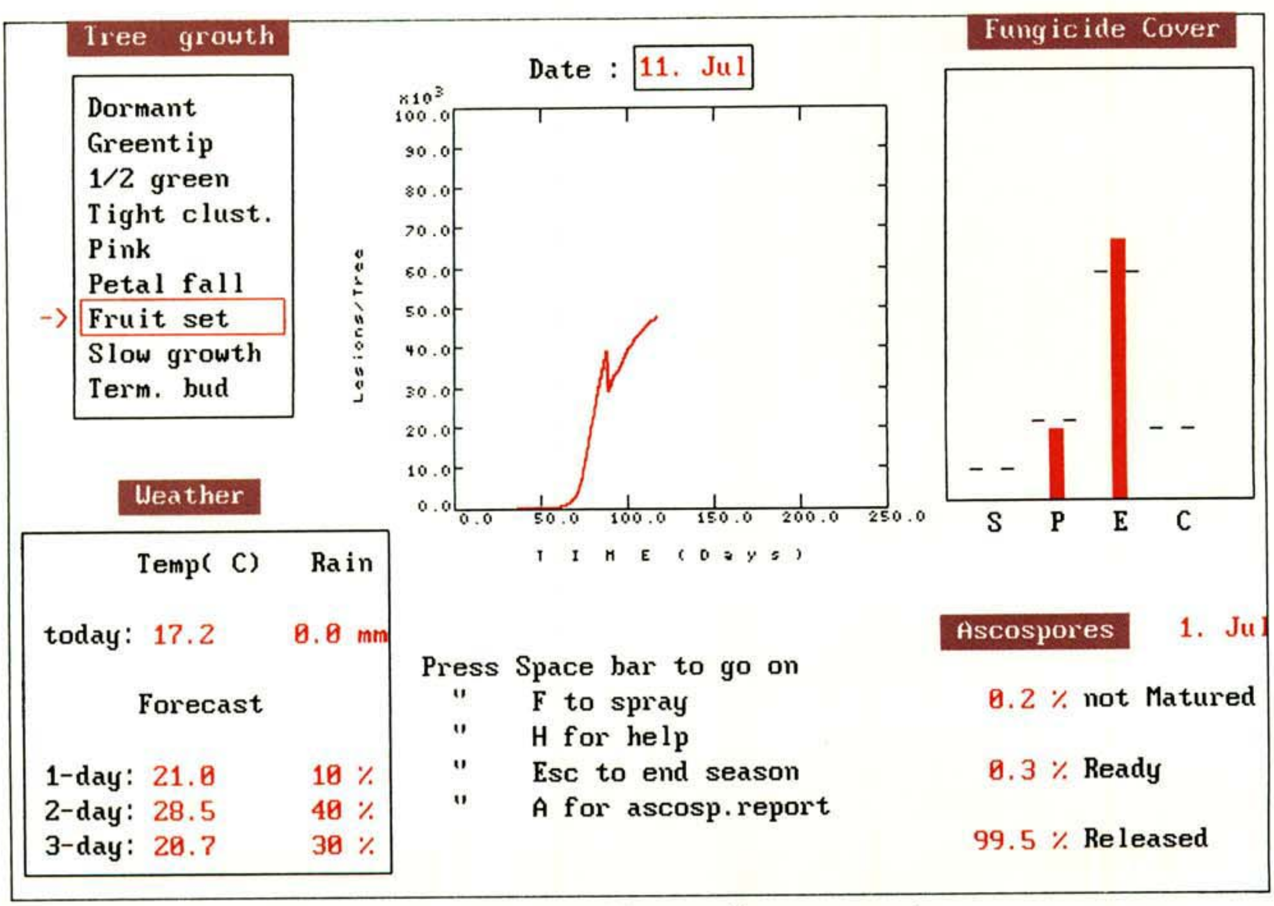

Fig. 3. The display during the game with fungicide cover and "on request" ascospore report.

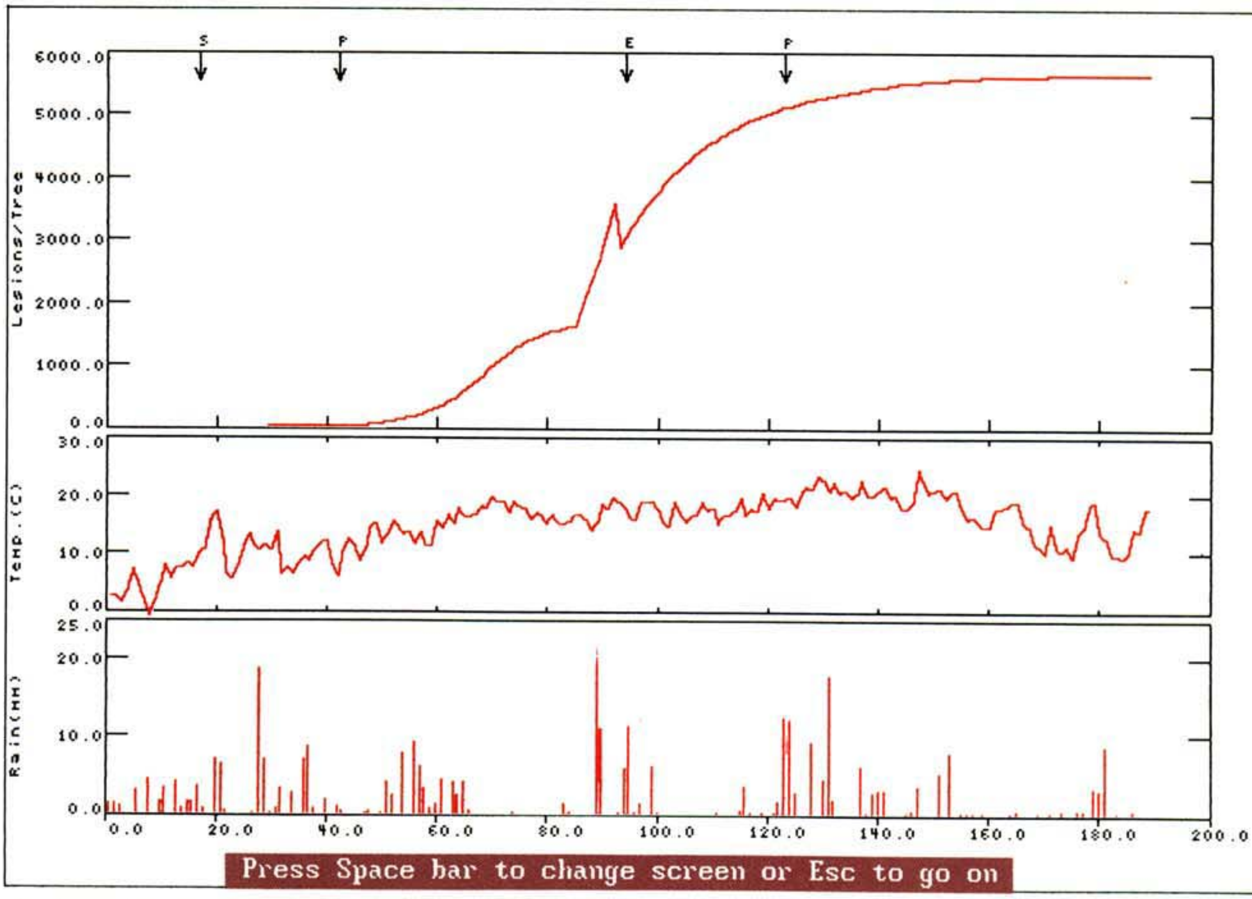

Fig. 4. The first display at the end of the season. The top graph shows disease development, with arrows indicating dates and type of fungicide sprays. The middle graph shows mean daily temperature, and the bottom graph shows rainfall.

FUNGICIDES COSTS

	Applications	costs($)
Satafol	1	400.00
Protectan	2	100.00
Eradican	1	100.00
Combocide	0	0.00
Total fungic. costs : $		600.00

COSTS OF ASCOSP. REPORTS

Weekly reports : $ 50.00

LOSSES DUE TO SCAB

Quality losses:	$ 270.42
Yield losses :	$ 4148.40
Total losses :	$ 4418.82

TURN OVER (/HA)

Quality	Price $/Kg	Quantity Kg	Total $
IA	0.60	12190.9	7314.55
I	0.45	1745.5	785.45
II	0.30	28.6	8.57
cook	0.15	0.1	0.01
	Total	13965.00	8108.58

Fungic. costs : $	600.00
Reports costs : $	50.00
Variable costs : $	1396.50
Fix costs : $	6000.00
NET RETURN : $	62.08

Press Space bar to change screen or Esc to go on

Fig. 5. The second display at the end of the season, giving the financial report.

whether residue information is provided and to select the frequency of ascospore reports. Reality is best reflected by eliminating all reports, but these reports can be very useful for learning purposes. The obligatory day-by-day step eliminates the risk of overlooking an important event. Moreover, the unlimited reflection time permits discussions of events and decisions. The ease of use allows concentration on the contents rather than on the operation of the program.

The use of the Pascal programming language, which is gaining in popularity among scientific programmers (5), facilitates insight into the program structure, and changes are therefore easier to implement. Weather and help data have been separated from the program so they can be replaced as desired.

The original mainframe version of APPLESCAB, which is one of the most widely distributed simulation programs in plant pathology, is implemented in more than 50 institutions. The wide distribution of personal computers and the reduced format of a disk should increase this number exponentially. For the first time, a simulation program is available in three languages—English, German, and French. This facilitates its use even further. We can agree with Teng and Rouse's (8) optimistic outlook that as microcomputers become more powerful and less expensive, epidemic simulations will gain more importance in plant pathology and that many of the large epidemic simulation models will be implemented on microcomputers (5).

Table 1. Computation time in seconds for a daily step and a whole season without intervention on two personal computers with different microprocessors

	IBM PC		Olivetti M24 (AT&T 6300)	
Processor	8088[a]	8088+ 8087[b]	8086[c]	8086+ 8087
Daily step	0.4	0.3	0.2	0.1
Whole season	48	24	24	12

[a] INTEL 8088: 16-bit microprocessor with 8-bit data bus, running at 4.77 MHz.

[b] INTEL 8087: Mathematical coprocessor.

[c] INTEL 8086: 16-bit microprocessor with 16-bit data bus, running at 8 MHz.

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Dr. Gessler is a research leader and lecturer in plant pathology at the Swiss Federal Institute of Technology. He received his Ph.D. degree in plant pathology at the same institution in 1977. His research interests center on two main subjects: induced resistance in plants and apple scab. He is particularly interested in incorporating basic research results in simulation of host-pathogen systems.

Ph. Blaise

Mr. Blaise received his M.S. degree in agriculture at the Swiss Federal Institute of Technology in 1983. He is currently working toward a Ph.D. degree in plant pathology. His thesis research deals with the simulation of apple scab epidemics in orchards with respect to ontogenic and varietal resistance to apple scab in apple leaves.

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Dr. Arneson is an associate professor in the Department of Plant Pathology at Cornell University, Ithaca, NY. He received his Ph.D. degree in plant pathology from the University of Wisconsin in 1967. As the teacher of courses in plant disease control and integrated pest management, he has contributed to the development of several computer simulation models for teaching disease management principles.