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Project No. 87-T13 - Almond Diseases
Shot Hole, Brown Rot, Green Fruit Rot, Leaf Rust

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Objectives: (1) Shot hole - Continue to develop biological data required for a forecasting system (IPM sponsored) and develop appropriate control measures based on fungicide mode of action. (2) Perfect the moisture generator and environmental monitoring system (MGEMS) for research on the blossom and fruit rot complex of Stigmina, Botrytis, and Monilinia. (3) Leaf rust - Develop control measures based on its speciation and life cycle of the pathogen.

Interpretive Summary: Shot hole disease on almonds was minimal in 1987 because of dry climate experienced from blossoming time to harvest. Two recent rainy periods, however, have triggered few leaf infections which are now sporulating. More rains before leaf drop could result in massive buildup of inoculum for spring 1988 infections. This conclusion is based on research by Dave Shaw, graduate student, on the "Effects of moisture and temperature on the infection of almond leaves by Stigmina carpophila". At temperatures above 15 C, 16 hours of leaf wetness was necessary for infection. At 8 C, however, up to 48 hours of leaf wetness was necessary for infection. After infection occurs, temperatures from 5 C to 25 C did not have a bearing on the number of lesions formed per leaf. Additional leaf wetness after infection may cause a higher amount of diseased tissue due to larger lesion size and coalescence. In addition extended periods of wetness enhance sporodochial development at temperatures above 15 C and more so above 22 C. Shotholing symptoms were more prevalent at high temperatures (22 C) than at low temperatures. Regarding disease control with fungicides, both copper and ziram acted as protectants with long residual activity, while captan had more suppressive action against the fungal spore germination but with shorter residual half life. Green fruit rot and leaf rust did not develop.

The Moisture Generator and Environmental Monitoring System (MGEMS) was perfected for reproduction of shot hole on leaves in orchard trees. Yet field trials on Merced almond trees failed to provide conditions for Monilina, Botrytis, Alternaria, or Pseudomonas syringae infections on young developing green fruit (Green fruit rot) when they were in the shuck-fall stage.

Brown rot blossom blight was reduced in an almond orchard with benzimidazole fungicide sprays in an orchard with 82% benomyl-resistant M. laxa populations but the disease incidence was extremely low. We would not expect benzimidazole fungicides (Benlate or Topsin M) to effectively control the disease under epidemic conditions nor in orchards with previous history of benomyl-resistant strains.. Alternative fungicides for benzimidazole fungicide is Rovral and Funginex and the experimental fungicides SC 0858, Prochloraz 50W, and Tilt 3.6 E.C. showed equivalent control of blossom blight caused by benomyl-resistant (82%) and benomyl-sensitive (18%) populations.

Experimental procedure

Specific data to be included in manuscript prepared for publication in PHYTOPATHOLOGY AND PLANT DISEASE as indicated under publications.

Shot hole disease: The Stigmina carpophila isolates used in the experiments were from diseased almond leaves from Modesto, CA and from Davis, CA. Other isolates used in the tests were from diseased twigs collected on peach and apricot trees on the Davis Campus. Spores were produced on potato dextrose agar medium and frozen in water at -15 C until use. The plant materials used were rooted almond trees (cv Carmel, Mission, Ne Plus Ultra, and Nonpareil) obtained from a nursery and planted in 4 L containers and six year old Carmel, Nonpareil and Mission cv trees grown on the experimental orchard on the Davis Campus. Spray inoculations of spores were made with a Paasche air brush and incubated in the dew chamber at various temperatures and wetness periods or branches of field trees covered with a plastic-paper bag. Evaluations were made on the disease development and sample lesions isolated to confirm infection was that of S. carpophila.

Moisture generator and environmental monitoring system (MGEMS): The MGEMS was constructed during the last project year. The only change was to add a device which quickly drained the excess water to prevent drip from nozzles after each spraying. The system was tested in production of the shot hole disease on almond leaves and brown rot blossom blight on apricots.

Brown rot blossom blight: The orchard used for the experimentation was located in Fresno County where about 80% of the M. laxa population was resistant to benomyl. Trees were hand gun sprayed at different time intervals during bloom. Data were obtained by counting the numbers of blighted twigs and examination of the attached blossoms for Monilia sporulation.

Results

Shot hole disease: The results of dew chamber and environmental chamber studies are presented in Fig. 1. to show the effects of temperature and moisture period on infection of almond leaves. Fig. 2 provides the data converted to give a picture of the response surface. Data on the rate of lesion development at three temperatures after 16 hr of leaf wetness at 15 C are provided in Fig. 3. Fig. 4 shows data on percent of lesions forming sporodochia under three moisture regimes at three temperatures while the percent of lesions showing abscission under the same moisture and temperature regimes.

MGEMS : Data to be presented in thesis (manuscript for publication) show doubling in numbers of shot hole lesions produced on leaves using the MGEMS equipment and significant increase from 0 to almost 5% in apricot blossom blight.

Brown rot blossom blight: Populations of isolates of M. laxa resistant to benomyl in an almond orchard located in Clovis, California were initially 75% and after 3 years 82% when only iprodione and triforine were used. In this orchard when low shoot blight incidence occurred, results of one pink bud spray using commercial rates of several fungicides showed average numbers of blighted shoots per tree as follows: Control 60.7, iprodione 14.0, benomyl 11.5, and carbendazim 13.8. In an apricot orchard with no benomyl resistant isolates of M. laxa and a high incidence of shoot blight the nonsprayed trees had an average of 74.0 infected shoots per 200 counted per tree while the iprodione treatment had only 15.0 and carbendazim 4.3 (Adaskaveg and Ogawa, 1987).

Investigations on the efficacy of new fungicides to provide an alternative for benomyl showed that an experimental fungicide SC-0858 (Stauffer Chemical Company, now ICI of England) was incorporated into Czapek's medium. On this medium both benomyl-sensitive and benomyl-resistant M. laxa mycelial growth but not that of spore germination. Hand atomizer sprays (300 ug/ml) at pink bud stage protected anthers and stigmas of Drake almond trees (Davis, California) from infection when artificial inoculations were made on blossoms opened in the laboratory. Handgun sprays on mature Ne Plus Ultra trees (Clovis, California) afforded effective control of blossom blight under natural disease conditions (Osorio, Ogawa, Feliciano, and Manji).

Discussion

Shot hole disease: Leaf infections during spring occur during periods when free moisture is deposited on the surface from rains, dew, fog, or sprinkler irrigation. Shotholing of lesions (abscission) would eliminate the diseased portion of the leaf which could produce new inoculum (sporodochia). Sporodochial production is dependent on presence of free moisture. Disease epidemic occurs under frequent wetness periods for infections and production of new inoculum. Under the disease management strategy under study, we plan on reducing the late fall infections which provide inoculum for spring infections by possibly spraying the trees with zinc sulphate. The first spring spray could be the one applied during pink bud (timing for brown rot blossom blight control) followed by another at the petal-fall to shuck-fall stage of blossom spray. Such strategy to be tested during 1988 would determine the number of sprays and timing required in orchards with high and low inoculum levels. Thus under low inoculum level conditions without sporodochial development on newly established infection in the spring, a single spray at either the pink bud or later could effectively contain the disease.

The current understanding of the disease cycle of the shot hole fungus on almonds in shown in Fig. 5.

MGEMS: This system can develop wetness periods for infection of the shot hole fungus on almond leaves and of the brown rot fungus on apricot blossoms. Such device would not only be valuable in developing parameters of forecasting diseases but in the testing of fungicide control measures. For almond disease studies, the MGEMS is planned for testing environmental conditions conducive for infections of blossoms by Monilinia, Botrytis, and Stigmina and for the evaluation of fungicides in control of these pathogens. If time permits, infection studies on almond fruit will be conducted with Stigmina.

Brown rot blossom blight: Benzimidazole-resistant strains of M. laxa have been detected in almond orchards of Fresno and Stanislaus counties. In the almond orchard where the original benzimidazole-R strain was detected, the resistance level to benomyl had not changed in the past five years although the orchard had not been sprayed with benomyl. Thus the only alternative in orchards where benomyl is effective is to continue to delay the selection by using benomyl only once during the season. In orchards with benomyl-R alternative chemicals such as iprodione and triforine is suggested.

The current understanding of the disease cycle of brown rot fungus caused by Monilinia laxa is shown in Fig. 6.

Publications

Adaskaveg, J. E., B. T. Manji, and J. M. Ogawa. 1988. Stability and control of benomyl-resistant populations of Monilinia species in the absence or presence of benzimidazoles. The American Phytopathological Society, APS Abtracts of presentation, 1987 APS Annual Mtg, Aug. 2-6. Cincinnati, Ohio. Abstract #494.

Ogawa, J. M., B. T. Manji, J. E. Adaskaveg, and T. J. Michailides. 1988. Population dynamics of plant pathogens resistant to benzimidazoles - A review of Monilinia species on stone fruits in California. North American Fungicide Resistance Workshop, The Pennsylvania State University, State College, PA. Sep. 20-25, 1987. 13 pp.

Osorio, J. M., J. M. Ogawa, A. J. Feliciano, and B. T. Manji. Efficacy of the experimental fungicide SC-0858 in control of brown rot diseases of stone fruits. American Phytopathological Society, Pacific Division, June 15-17, 1987. Coeur D'Alene, Idaho. Abstract.

Shaw, D. A., J. E. Adaskaveg, and J. M. Ogawa. 198_. A moisture generator and environmental monitoring system (MGEMS) for field studies on shot hole and brown rot diseases of fruit and nut trees. Plant Disease (In preparation)

Shaw, D. A. J. E. Adaskaveg, and J. M. Ogawa. 198_. Effects of moisture and temperature on the development of shot hole disease caused by Stigmina carpophila. Phyotopathology (In preparation).

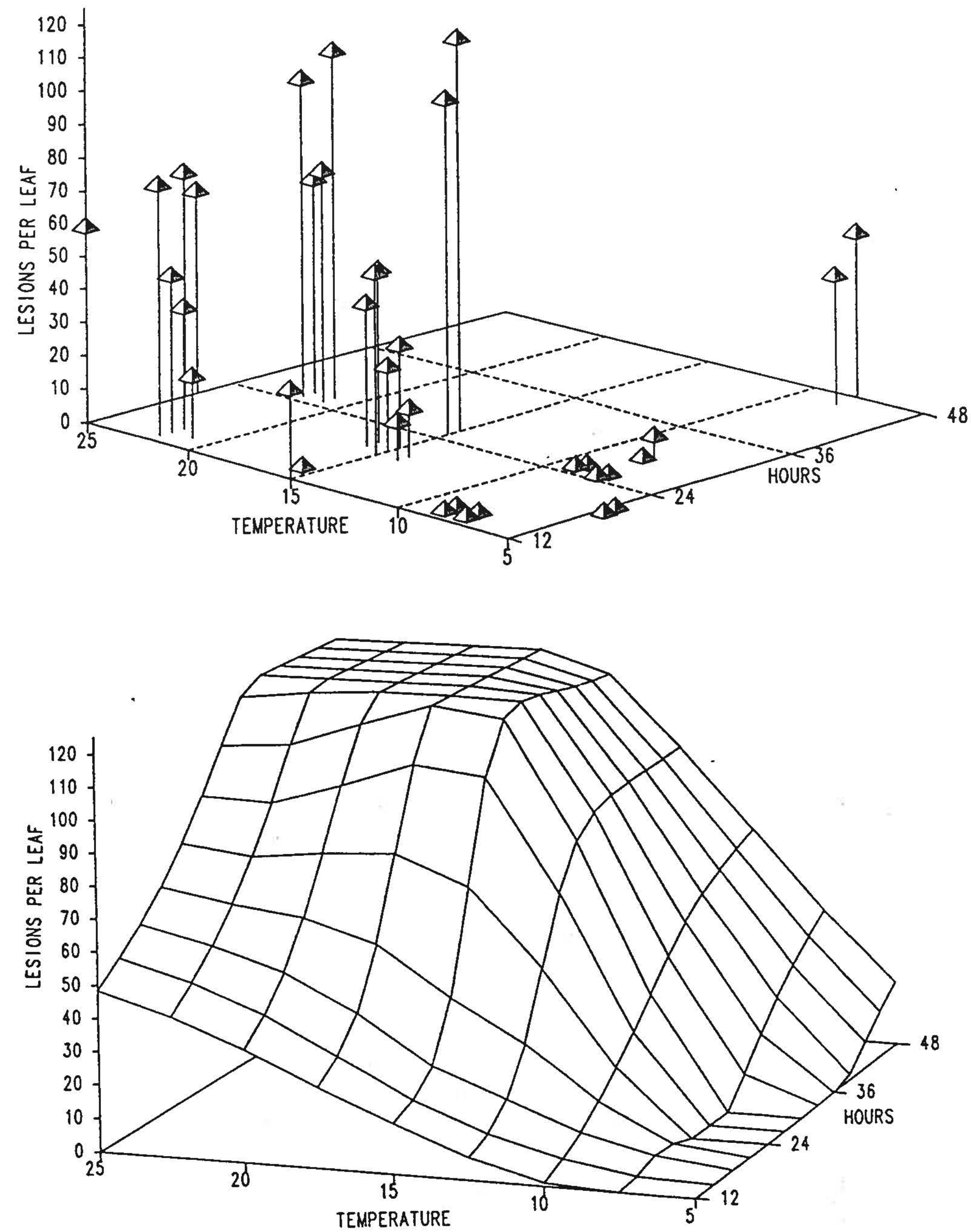

Fig. 1. Effect of temperature and moisture period on infection of almond leaves.

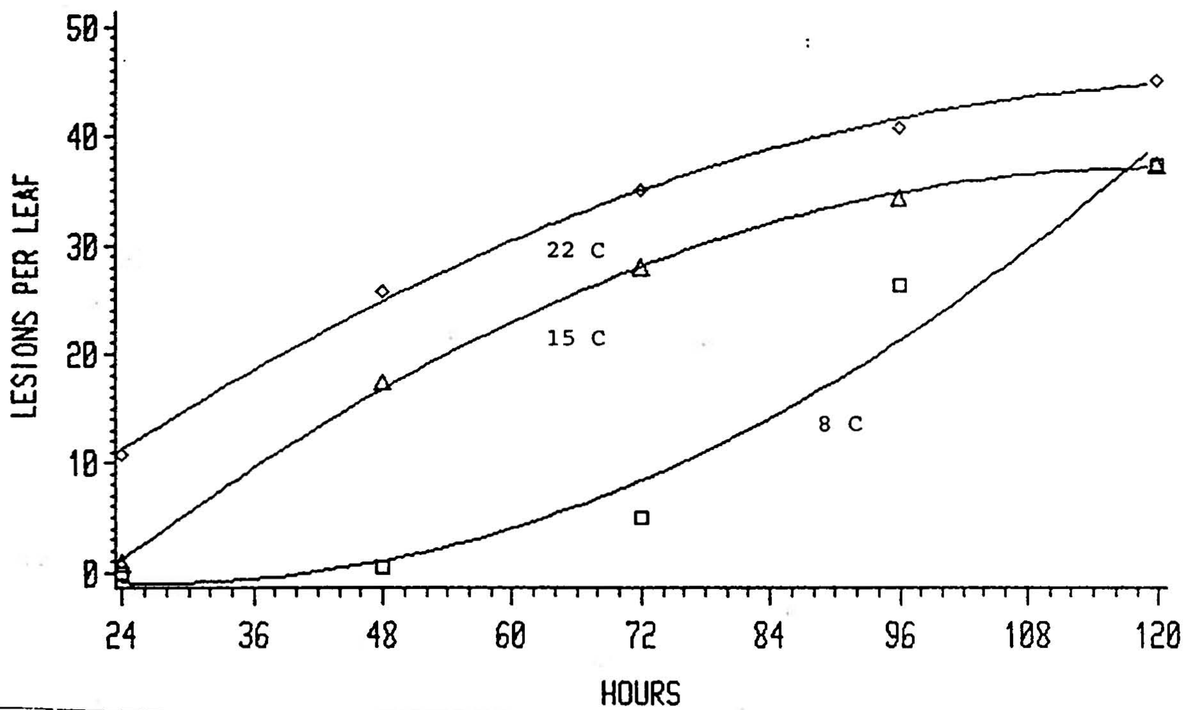

Fig. 2. Rate of lesion development at three temperaturs after 16 hr of leaf wetness at 15 C.

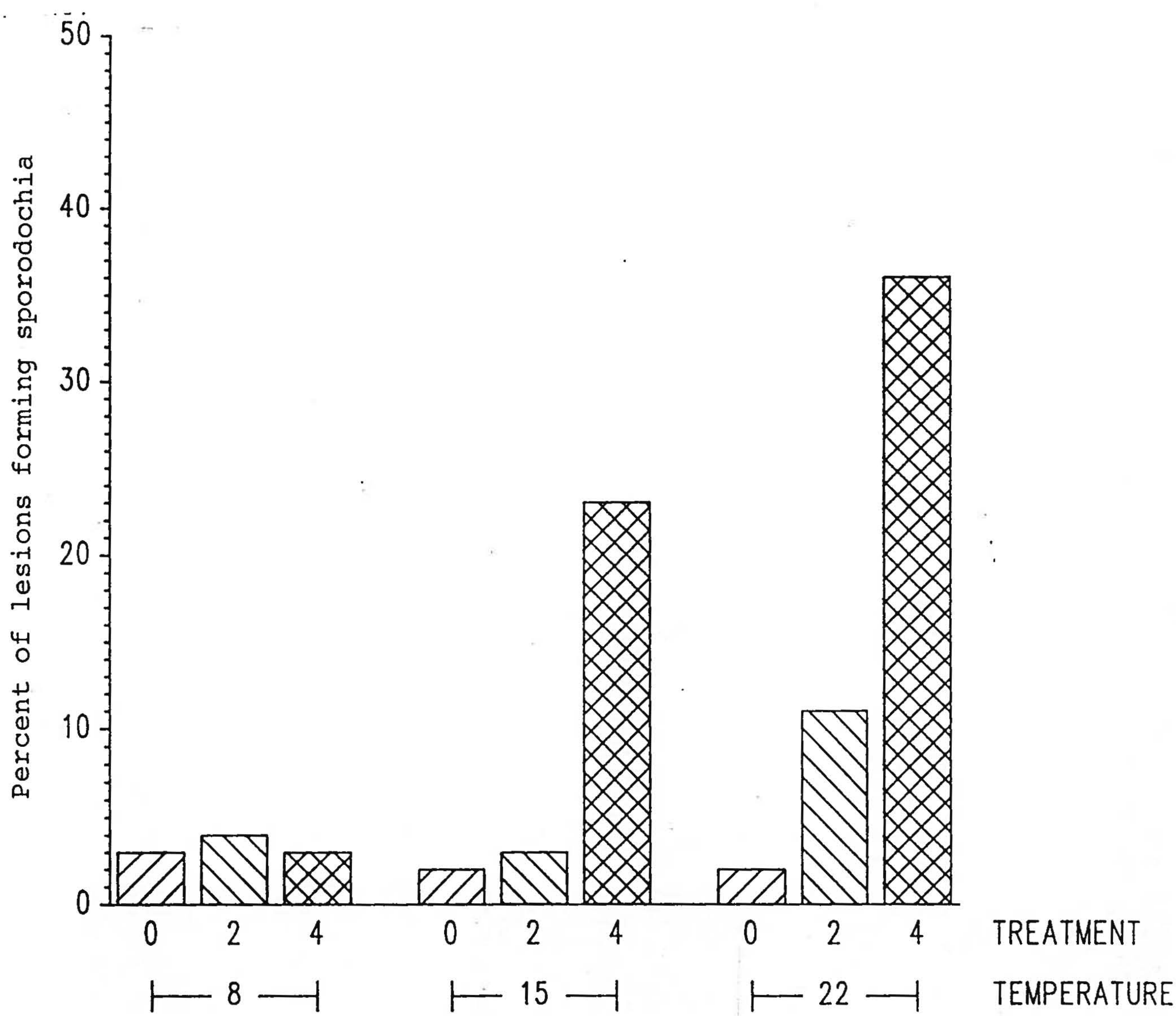

Fig. 3. Percent of lesions forming sporodochia under three moisture regimes at three temperatures.

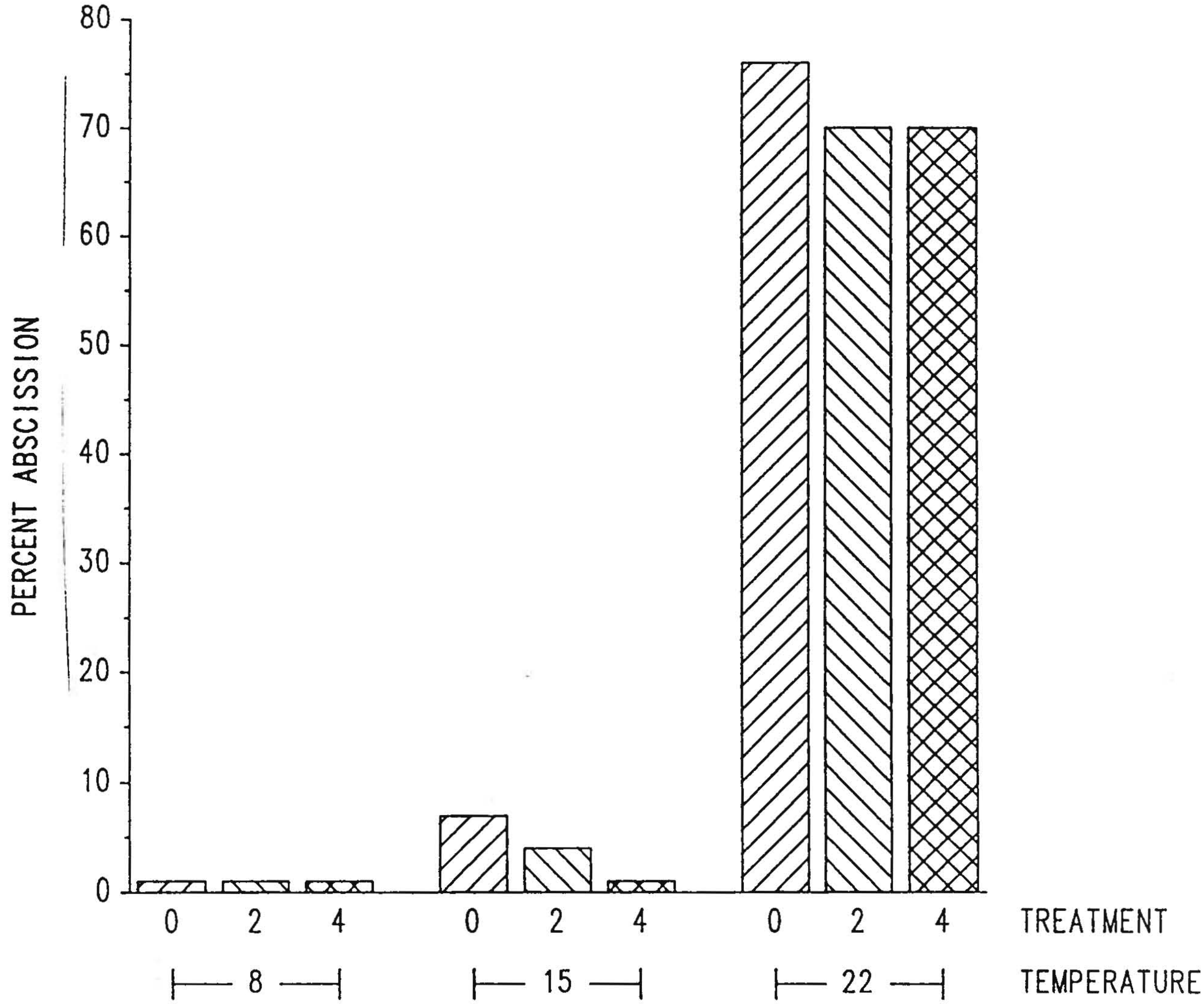

Fig. 4. Percent of lesions showing abscission under under three moisture regimes at three temperatures.

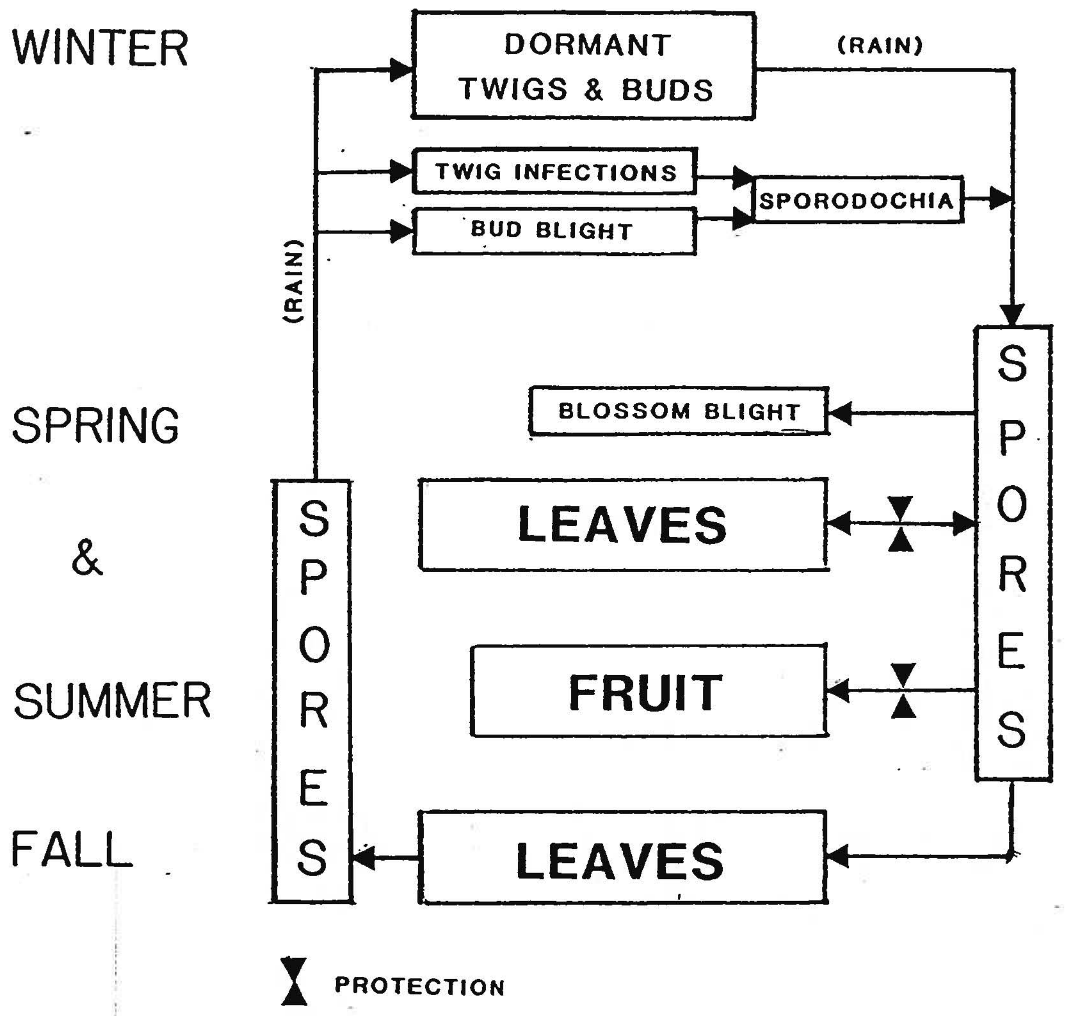

Fig. 5. Disease cycle of the shot hole fungus, *Stigmina carpophila*, on almonds.

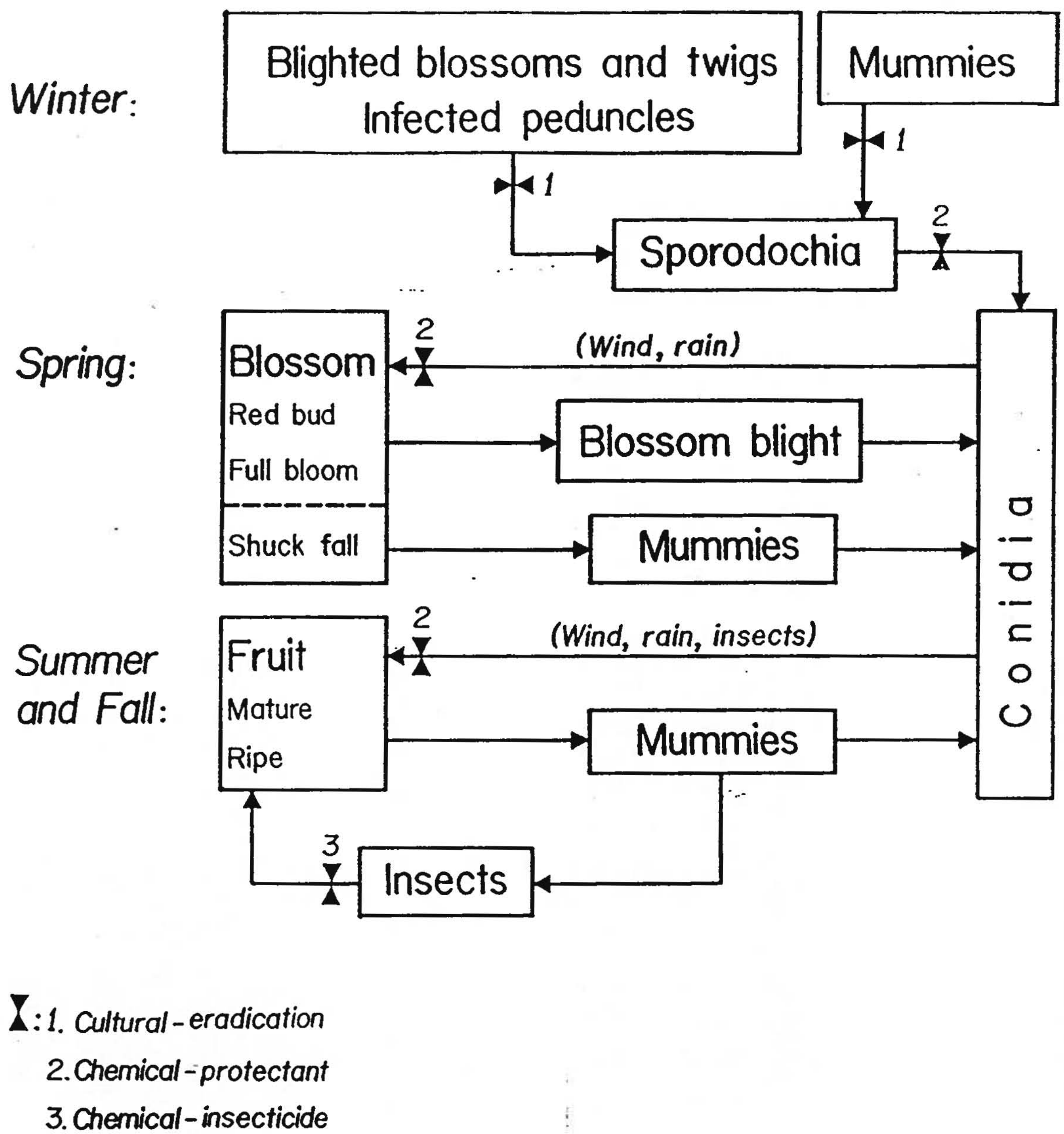

Fig. 6. Disease cycle of the brown rot fungus, Monilinia laxa on almonds.