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Assessing Plant Problems in Cropping Systems: A Systematic Approach[1]

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INTRODUCTION: The ability to assess plant problems in the field or greenhouse is a major task for growers and plant inspectors. For the novice diagnostician, the task can be intimidating in the absence of a systematic plan for discovering the causes of plant injury. For the more accomplished diagnostician, use of a systematic approach can help avoid the bias of looking only for the familiar syndrome and stopping the investigative process prematurely.

This circular presents one such systematic approach to assist in the assessment of any plant problem. Determining what injured or predisposed a plant to injury requires keen observation skills, and the ability to investigate and consolidate information so that causal events can be reconstructed. In trying to determine what has caused an incident of plant damage, a sequence of deductive steps can assemble clues and information from the larger setting and point toward the specific problem. The attached plant problem diagnostic flow chart (Fig. 1) uses a process of deduction and elimination to arrive at the most probable cause of a plant problem. The flow chart also directs the investigator where to go if further assistance is required (Green *et* al. 1990; Grogan 1981).

STEP A: DEFINING THE PROBLEM. First determine if a problem actually exists. Identify the plant (genus, species and cultivar/variety) so that a basis exists for defining its normal characteristics at the current season and age. This information may come from personal knowledge of the plant and its characteristics, consultation with experts or from published references. Many plants may appear abnormal to someone unfamiliar with the normal characteristics of the crop (Green *et al.* 1990; Grogan 1981). Some examples of `normal' plant morphology that could be misinterpreted as `abnormal' are unusually large leaf glands or twig lenticels, synchronous leaf drop from conifers and broadleaf plants, variegation or seasonal foliage coloration, drop of part of the immature fruit crop, leaf or root senescence coupled with dormancy, or slow growth rate. Compare the `abnormal' plant's morphology and growth patterns with that of a healthy plant. Describe the `abnormality' to delineate the symptoms associated with the problem. Remember that while symptoms may indicate something is wrong, they are not necessarily indicative of the nature or location of the causal agent, especially when symptoms are caused by root impairment or improper soil conditions (Green *et al.* 1990; Grogan 1981; Schubert *et al.* 1988). If the plants are deemed abnormal, proceed to step B. This flow chart is specifically designed for use on cropping systems and other managed plant production systems where growers are trying to create a plant that fulfills specific requirements desired by the marketplace. Thus, there may be cultural practices used to enhance a particular plant characteristic that would appear quite different in the native wild habitat. The chart can also be adapted for use in natural ecosystems.

STEP B: CHECK FOR PATTERNS AND DELINEATE TIME-DEVELOPMENT. Pattern development and recognition of symptom patterns coupled with knowledge of the time frame for development of symptoms are two of the most important clues for distinguishing between living (biotic) and non-living (abiotic) causal agents. Pattern development and time frames involved with the syndrome should be viewed stepwise, starting

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with the individual plants, then the whole crop, and finally the surrounding plant community (Green *et al.* 1990; Grogan 1981; Schubert *et* at. 1988). This is the time for gathering the complete history of the crop. History of the crop includes what has been done to the crop and when these events occurred. Other useful information to consider is climatic data and other predisposing factors, especially soil and water conditions.

With <u>biotic</u> causal agents, *usually* there is no widespread, uniformly repeating pattern of symptoms, and the syndrome develops gradually over time, both on the individual plant and on the whole crop **(step B.1** in the flow chart) (Green *et al.* 1990; Schubert *et al.* 1988). Following the flow chart should take you to the biotic section in step C.1.

With <u>abiotic</u> causal agents, uniform symptoms *generally* appear all at one time, and *usually* the injury does not continue to spread either throughout the individual plant or onto unaffected plants **(step B.2** in the flow chart). Many times there is a very clear demarcation between injured tissue and healthy tissue on the plant. Depending on the abiotic causal agent, damage may be widespread including different crops and perhaps the surrounding plant community (Green *et al.* 1990; Schubert *et al.* 1988). The absence of a clear biotic primary causal agent (as determined in the laboratory) reinforces the abiotic diagnosis, especially if the samples are acquired promptly after the damage event. Samples collected late can be overrun by opportunistic fungi and bacteria, confounding the distinction between the abiotic and biotic diagnosis. When the clues are relatively clear in pointing to synchronized timing of symptom appearance and an obvious pattern, this situation should bring the investigator to the abiotic causal factor section in step C.2.

Step B.3, <u>situations with complex etiology,</u> accommodates several different symptoms and/or patterns of distribution within the crop -- for example, when treating a causal factor does not correct the problem, when treatment is only partially or temporarily corrective, or when the timing of symptom appearance is muddled. This suggests the involvement of multiple events and/or causal agents (Green *et al.* 1990; Grogan 1981; Schubert *et al.* 1988). These complex situations lead to step C.3 in the flow chart.

STEP C: REFINE THE DIAGNOSIS. In **step C.1,** the objective is to determine what biotic agent might be involved in the plant damage. Observation and notation of the symptoms and signs (i.e., the syndrome) of the causal agent are required. **Symptoms** are the modified appearance expressed by the damaged plant (galls, necrotic tissues, stunting, chlorosis, distortion, etc.), while **signs** are evidence of or the actual presence of the causal agent. Signs may include insect frass, fungal mycelium or spores, bacterial ooze or the actual observation of the insect, mites, rabbits, deer, etc. (Green *et al.* 1990; Schubert *et al.* 1988). With this information, the investigator should have an idea of whether the problem is from a pest or a pathogen, and move on to step D.

Step C.2 involves sorting out the abiotic agents. Some of these factors (mechanical, environmental, and chemical) may overlap. For example, broken limbs (mechanical) caused by strong winds (environmental), or pesticide contact phytotoxicity (chemical) under high temperatures or water stress (environmental) may all be present. When working with a chemical causal agent, two main categories emerge: injury caused by nutritional disorders or phytotoxicity from pesticides or pollution. Occasionally, an abiotic agent will leave a sign, such as visible pesticide residue, a hailstone, or charred/splintered tissues from a lightning strike. More often, however, one must rely heavily on a review of management practices, attempting to correlate these with the timing and nature of symptom development. From there, the investigator can decide whether a nutritional disorder or phytotoxicity has occurred, leading to step D (Green *et al.* 1990; Schubert *et al.* 1988).

In **step C.3** the investigator is usually confronted with multiple patterns of distribution and/or symptoms. We suggest breaking the complete syndrome down into smaller parts. Start by looking at each primary plant symptom and list the possible causes for that symptom. Then list suspected causal factors suggested by the pattern of all the individual symptoms observed. Take each list and match the possible causal factors with known management practices, soil factors, environmental events and host plant predispositions. Factors contributing to this category of complex plant problems include genetic factors, soil conditions, exopathogens, iatrogenic problems, allelopathic agents and any other predisposing or unknown factor(s) that resulted in plant injury. Idiosyncrasies of the particular plant should be considered at this stage as well. The well-known example of tomatoes and other plants not being able to grow in the vicinity of walnut trees illustrates an **allelopathic relationship** (the detrimental effect that one plant exerts upon another plant caused by the release of a chemical substance) (Putnam 1978). The frenching disease of tobacco occurs when conducive soil conditions prevail in the presence of the soil bacterium *Bacillus cereus.* This is an example of an **exopathogen** (exopathogens are microorganisms that live outside plants and induce disease mainly by secreting phytotoxic substances that the plants absorb) (Woltz 1978). Diseases which are increased in their severity or are a result of the use of agrichemicals/pesticides are referred to as **iatrogenic diseases.** The use of soil-applied herbicides frequently exacerbates non-target seedling diseases from unspecialized fungal pathogens such as *Pythium, Phytophthora, Rhizoctonia* or *Fusarium.* This is due to the fact that some soil herbicides increase leakage of root metabolites which stimulate pathogen growth within the rhizosphere (Griffiths 1981). An illustration of a **genetic abnormality** would be the tendency for certain palm species to demonstrate albinism in a small percentage of the seedling crop, or the appearance of chimeric tissues on citrus fruits and foliage. Cold intolerance of tropical plants is an example of a **plant idiosyncrasy** that can present unexpected and mysterious symptoms. Cold water ringspots on gesneriad foliage and subtle olive-green water-soaked blotching of aglaonema foliage after exposure to temperatures around 45-50 F fit this category (Henley 1983). Complex plant damage events may require several investigative attempts before an understanding of the total problem is achieved. For this reason, it is not uncommon to follow step C.3 to step D, and then return to any of the stages in step C.

An elementary example of resolving a somewhat complex abiotic plant problem follows. Consider a bean *(Phaseolus vulgaris)* field where all the plants in one corner are exhibiting tip dieback and marginal leaf scorch. The affected plants appear to have developed the syndrome at about the same time. A review of the grower's management practices indicated there had been a fertilizer application a week prior to symptom development. The environmental conditions after the application were a slight amount of rainfall followed by dry, sunny weather. The affected corner of the field is characterized by higher elevation and a drier soil type than the rest of the field. A predisposing plant factor was a sensitivity to soluble salts (fertilizer). The determination of fertilizer burn from excess soil soluble salts was arrived at by assembling in a systematic way the following pieces of information: (a) **pattern of injury on individual plants --** tip dieback and marginal scorch; (b) **pattern in crop --** one field corner only; (c) **time frame for symptom development --** all at one time; (d) **management practice --** fertilization; (e) **environmental events --** slight rain followed by dry weather; (f) **soil factors --** drier soil in that area of the field; and (g) **predisposing plant factors --** salt sensitivity of bean. The grower could confirm this presumptive diagnosis with a soil test for total soluble salts (an option in step D).

STEP D: CHECK REFERENCES AND PERFORM LABORATORY ANALYSIS. Here the investigator checks the reference literature that describes problems associated with a certain plant (Green *et al.* 1990). Some situations may have numerous possible causal agents, each needing investigation. For example, uneven seed germination in a field may be the result of such things as poor planting practices, poor seed quality, bird predation, insect injury, cold soil, water stress or a disease problem. Researching the literature often helps to alert the reader to predisposing factors, management practices or other contributing or synergistic factors surrounding the problem. A laboratory analysis may be needed to either narrow down the possible causal factors, or provide a definite diagnosis of a biotic causal agent. Generally, you should now have an idea of which specialist (plant pathologist, soil scientist, botanist, horticulturist, agronomist, entomologist, nematologist, etc.) to contact and what reference books to use for further assistance concerning the problem (Green *et al.* 1990). The investigator with library and Internet access along with established, willing and competent colleagues in each of these disciplines is at a decided advantage at this point. Locating a single publication on your specific topic or a related topic and reviewing its bibliography can open up an entire area of new reference works. Often, the new information gleaned at this step sends the investigator back around the diagnostic flow chart, using the feedback pathway. By utilizing the feedback loop in the chart a more complete understanding of the problem may be achieved.

STEP E: SYNTHESIZE THE DIAGNOSIS. By synthesizing all of the above information the final step in the diagnostic flow chart is reached (Green *et al.* 1990). Although missing or sketchy information is not desirable, neither is it fatal to the diagnostic process. Working through the diagnostic steps and using the available knowledge and information could still yield valuable insights and possible answers. While some plant problems are very straightforward (such as late blight on potatoes caused by *Phytophthora infestans)*, many are multi-faceted situations.

When faced with these multi-faceted situations there are several techniques the grower can use to help organize the information. The first tool is to list the probable causal agents and rank them in order of importance, based upon their impact on production. The second tool is to make a diagram depicting the different causal factors and their relationship to each other as well as to the host plant. A simple example of the usefulness of this exercise is the relationship between soil pH extremes, how that relates to availability of micronutrients such as iron, manganese, zinc and copper, and the symptoms of deficiencies or toxicities of these elements. Both of these tools can help the investigator organize the different elements of the problem into a holistic model of the situation. The grower may then see where in the production process they can intervene and what types of intervention are available and affordable to meet their production goals.

It is axiomatic in plant pathology that the first phase in disease management is correct diagnosis. The systematic approach to plant problem assessment as presented here offers a powerful and accurate tool for improving the likelihood of a correct diagnosis.

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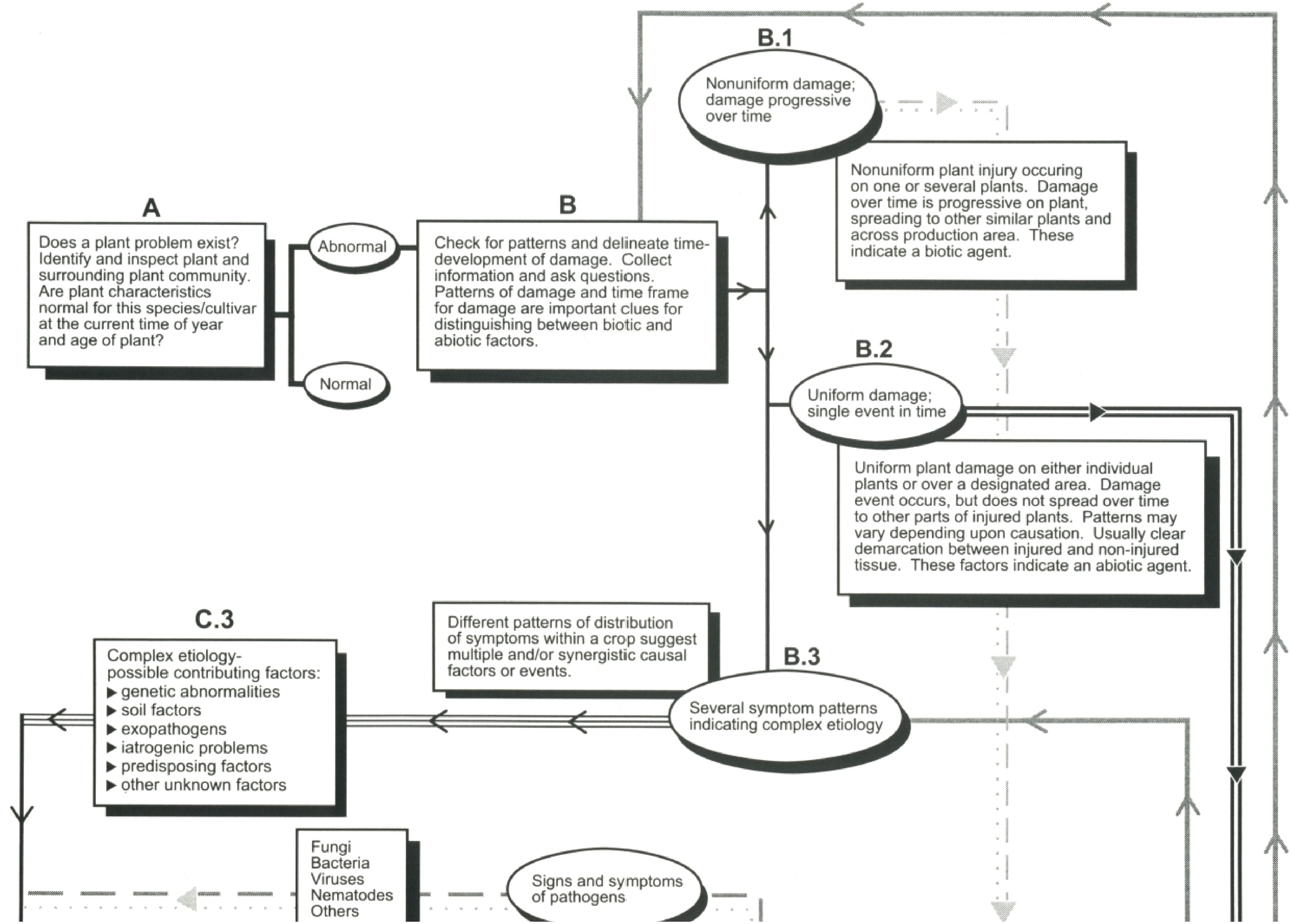
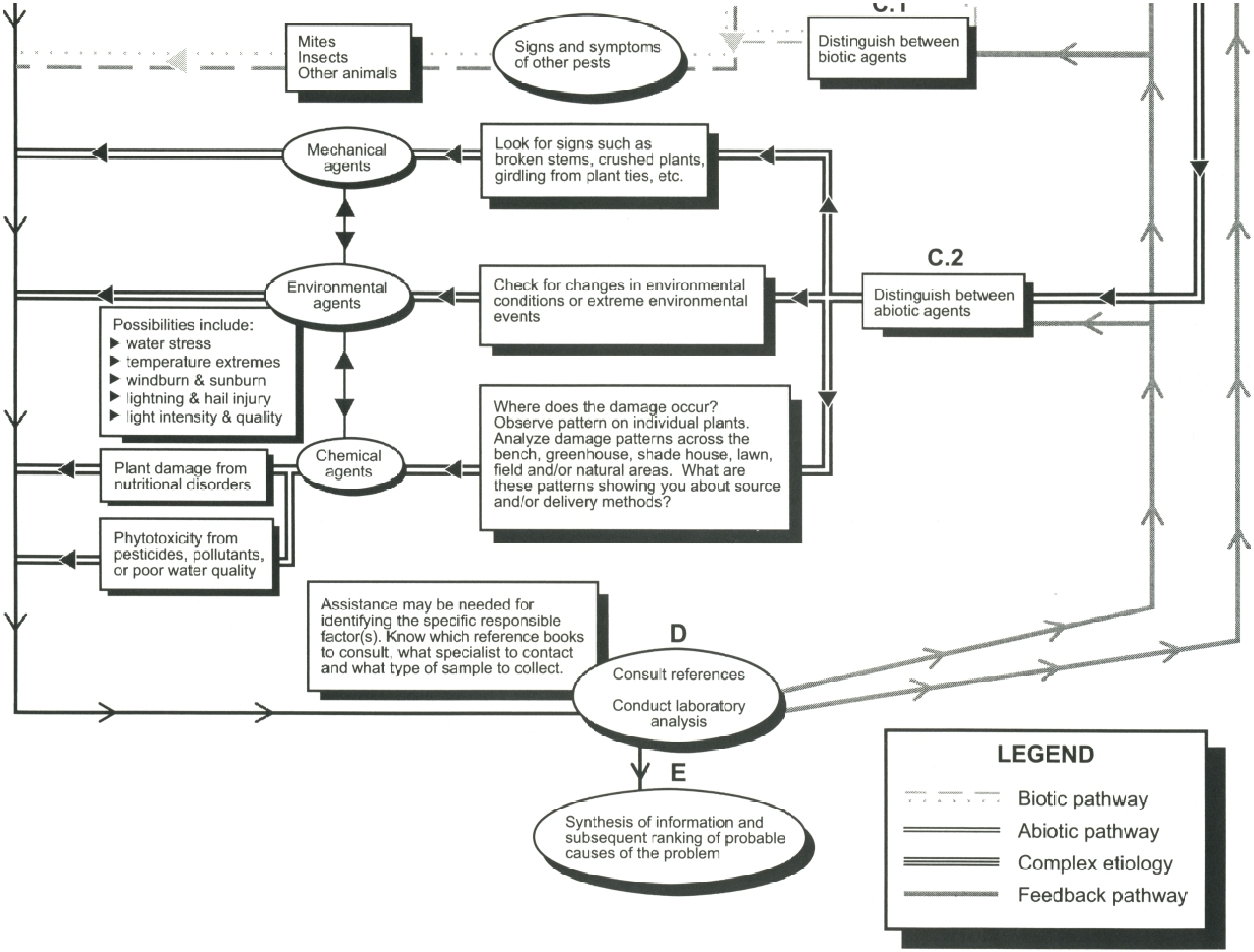
PLANT PROBLEM DIAGNOSTIC FLOW CHART




C.1
Distinguish between biotic agents
Mites
Insects
Other animals
Signs and symptoms of other pests
Mechanical agents
Look for signs such as broken stems, crushed plants, girdling from plant ties, etc.
C.2
Distinguish between abiotic agents
Environmental agents
Check for changes in environmental conditions or extreme environmental events
Possibilities include:
▶ water stress
▶ temperature extremes
▶ windburn & sunburn
▶ lightning & hail injury
▶ light intensity & quality
Chemical agents
Where does the damage occur? Observe pattern on individual plants. Analyze damage patterns across the bench, greenhouse, shade house, lawn, field and/or natural areas. What are these patterns showing you about source and/or delivery methods?
Plant damage from nutritional disorders
Phytotoxicity from pesticides, pollutants, or poor water quality
Assistance may be needed for identifying the specific responsible factor(s). Know which reference books to consult, what specialist to contact and what type of sample to collect.
D
Consult references
Conduct laboratory analysis
E
Synthesis of information and subsequent ranking of probable causes of the problem
LEGEND
Biotic pathway
Abiotic pathway
Complex etiology
Feedback pathway