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# Decision process under greenhouse

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## Abstract

Greenhouse environmental control and production management is not an easy task. Automation or atleast supporting the decision making process is becoming an increasingly important issue in order to master this complexity and make a more rational use of resources. In order to support the greenhouse user in decision-making, the knowledge of scientists, advisors and growers must be implemented into practice in the form of a computer programme. The choice of set points for environmental parameters must be done by a reasoning process integrating the situation outside the greenhouse, inside situation that we want to manage in an advantageous manner ensuring a profitable, though safe combination of growth and development factors while keeping the energy spending within acceptable bounds and as low as possible.

**Key words:** Decision process, greenhouse, environment

In agreement with the decisions that lie between strategy formulation and its implementation, we consider a decision process structured in a tree level hierarchy going at the bottom (level 1) from online climate control through (level 2) the tactical decision level concerning the determination of daily set points and to the higher (level 3) seasonal planning. The first level encompasses a set of regulation algorithms that aim at controlling the important (and controllable) climate parameters. The automation of the short-term decision process at this level is fairly well mastered (although some improvements are still possible) in modern, well - equipped greenhouses. The second level deals with deciding the appropriate daily settings depending on the actual status of the crop (growth stage, vigor), weather conditions and timing situation with respect to the specified overall planning. The involved decisions concern the environment set points of a particular day but the reasoning needed to reach these decisions must span a several day time scale. Finally, given the general goal of maximizing the profit of the grower, the upper level, is still to be explored. The upper level deals with the appropriate decomposition of the crop production season in growth stages and the determination of the corresponding mean inside temperatures according to constraints related to mean outside climate, crop growth and development, etc. The details of the decision process have been included in the paper.

Many studies have indicated the importance of environmental control in covered cultivation. Keeping this in view, Burrage *et*

**Table 1. Stages of growth and corresponding objectives**

| Stage | Initial stage | Final stage | Duration (days) | Morphological objectives and recommendations | Climate management, objectives and recommendations |
|---|---|---|---|---|---|
| 1 | Planting | Flowering | 19 | Develop root system, maintain vegetative balance | Maintain air/soil temperature, maintain solar radiation/air temperature balance, avoid low humidity in the first part of stage |
| 2 | Flowering | Fruit setting | 31 | Help fruit setting, maintain vegetative balance, prevent incidence of diseases | Maintain solar radiation/air and soil temperature balance, be careful with high humidity at the end of stage |
| 3 | Fruit setting | First picking | 44 | Maintain vegetative balance, prevent incidence of diseases | Maintain solar radiation/air and soil temperature balance, optimize the choice of mean air temperature with respect to available solar radiation, be careful with high humidity at the end of stage |
| 4 | First picking | Last picking | 65 | Help fruit growth, maintain vegetativebalance, make sure water and nutrition are correctly supplied | Prevent too high air temperature, prevent diurnal low humidity, manage water and nutrition supply with respect to climate conditions |

*al.* (1988) developed a microcomputer - based environmental control system for mushroom cropping tunnels. Jones *et al.* (1989) studied coupling of expert systems and models for the real -time control of plant environments and described a control system to regulate $CO_2$ in a plant growth chamber. $CO_2$ controls were based on a model of plant photosynthetic light response. Parameters in the model that change through time were automatically evaluated and updated on a daily basis. Ehler *et .al.* (1996) and Kidmanee *et al.* (1995). Control of flowering can also be done by proper control of the environment (Ehler *et al.*, 1996) and nutrition management (Fynn *et al.*, 1989). A decision support system for single truss tomato production was subsequently reported by Ting *et al.* (1993). In this production system each plant was allowed to produce only one truss of fruits.

**Basic knowledge involved in the determination of climatic setpoints:** In the problem of climatic setpoints determination one has to take care of and integrate the following two classes of parameters: the situation outside the greenhouse, expressed through air temperature, humidity, solar radiation, direction and intensity of wind; the inside situation that we want to manage and which may be evaluated through both quantitative measures of air temperature, soil temperature and the saturation deficit and a qualitative appraisal of some physical aspects of plants including especially the stage indicators and symptoms of diseases, wilting or too strong vigour.

The setpoints are another class of variables whose values specify the domains outside of which the control computers must command the use of a device such as the heating system (start or stop).

**Factors in managing decisions:** The choice of setpoints must be done by a reasoning process integrating the above-mentioned parameters in an advantageous manner ensuring a profitable, though safe, combination of growth and development factors while keeping the energy spending within acceptable bounds and as low as possible. Managing the production aims first at controlling the basic physiological functions such as photosynthesis, respiration, assimilation and transpiration that underline the growth and development of plants. Roughly one can consider that growth is essentially affected by the intensity and duration of solar radiation that provides the energy needed in the photosynthesis process whereas development is directly linked to the amount of heat (temperature) received over a period. Temperature also influences the rate of photosynthesis and thus the rate of growth.

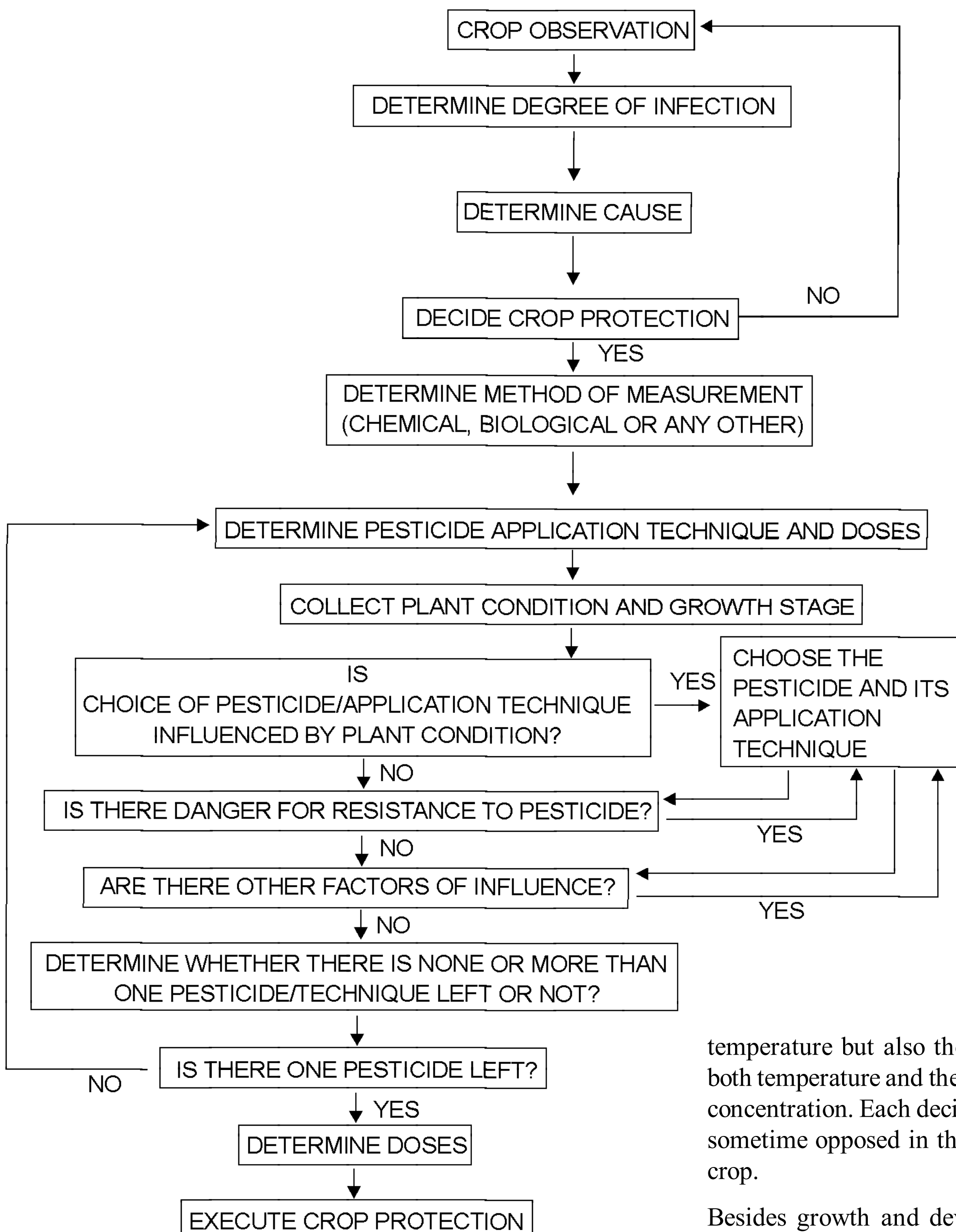


**Fig. 1. Decision making process for the choice of pesticide and an application technique**

The main parameters describing the inside climate (light, temperature, and saturation deficit/relative humidity) interact with each other; few interventions (heating, ventilating, and shading) act preferentially on one particular parameters but modify also several others. For example, heating affects temperature but also the saturation deficit, ventilating affects both temperature and the saturation deficit and modifies the $CO_2$ concentration. Each decision has complex repercussions that are sometime opposed in their more or less delayed effects on the crop.

Besides growth and development factors care must be taken beforehand to prevent undesirable situations. This concerns in particular the incidence and development of diseases or infestations by parasites. Essentially the management decisions must ensure that conditions of high humidity (low saturation deficit to be more exact) are avoided.

Simple rules, induced from the observed practices of experienced growers, tell that the appropriate reaction in case of a too strong vigour is to increase the mean (over the day) air temperature, decrease the soil temperature and lower the humidity (*i.e.* increase the saturation deficit). A too weak vigour is also unsuitable and can be corrected by the converse actions.

**Stages of growth:** It is clear that the above factors are more or less relevant or important depending on the stage of growth of the plants. Each stage corresponds specific rules used in the decision process. Generally, we consider four main stages that practically correspond to uniform morphological objectives and monitoring management recommendations. Each stage is characterized by a sum of degree-days that the plants must receive within. An example of decision process for the growth stages of tomato (Naveen variety) is given in Table 1.

**Crop protection system:** Crop protection system is required to control the development of disease or infestation by parasites and to increase the quality. A decision process for greenhouse crop has been developed to assist the grower with respect to crop protection. The system contains the following functions: crop observations and measurements; survey of observed data; advise on the basis of the observed data; information about pesticides, pests/diseases and parasites. A decision model which describes the ideal approach for crop protection has been divided into different steps. Each activity of decision model has been worked out into flow diagrams describing the decisions as 'yes-no' questions. A decision making process for the selection of a pesticide and the application technique is given in Fig. 1. The factors influencing the selection of pesticides are also indicated in the flow diagrams. Under the given situation if a factor plays a role, then a selection is made.

To summarize all the steps and decisions based on the decision model, a checklist has been set up. The decisions to decide crop protection and pesticides selection have also been worked out in the programme.

The system is being developed based on collected knowledge. The experiences obtained can be used as a tool for greenhouse crop production.

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