Teaching Methods

Using Web-based Distance Learning Methods to Teach Nutrient Management Planners

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SUMMARY. The State of Maryland Legislature enacted the Water Quality Improvement Act in 1998, which requires all agricultural operations to develop and implement nitrogen- and phosphorus-based nutrient management plans by December 2002. This legislation also mandates the education and training of professionals who will write nutrient management plans, and growers who will implement them. Maryland Cooperative Extension faculty have therefore been charged with developing effective educational programs that will enable nursery and greenhouse industry professionals to achieve these goals and ensure industry compliance with this legislation.

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Newly enforced provisions of the Federal Clean Water Act of 1972 (Environmental Protection Agency, 2000) and new state regulations that enforce the Maryland Water Quality Improvement Act of 1998 (Maryland Department of Agriculture, 2000) are ensuring that agricultural operations develop effective procedures to show that they are not polluting our nation's water resources. The Maryland law is presently the toughest nutrient management law in the nation, requiring virtually all agricultural operations to write and implement nitrogen- (N) and phosphorus- (P) based management plans by Dec. 2002 (Maryland Department of Agriculture, 2000). This law was passed in reaction to an outbreak of the organism *Pfeistieria* in some tributaries of the Chesapeake Bay that induced fish kills and had negative health effects on some local fisherman. A blue-ribbon panel determined that the most probable causes of this *Pfeistieria* outbreak were poor water quality, excess nutrients, and especially high levels of phosphorus in tributary waters of the Chesapeake Bay.

The Maryland nutrient management legislation poses unique challenges for the nursery and greenhouse industry because a wide range of production scenarios are used to produce a large number of different species and types of ornamental plants, usually on small acreages. Formulating a planning process that takes into account both water and nutrient applications is very important for these types of operations, as cultural practices and site conditions may be conducive to nutrient leaching and runoff (Ross et al., 2001a). Many operations already have implemented improved management practices to conserve water and nutrients (Ross et al., 2001b). Operations that do not already have such procedures in place will have to find cost-effective ways to comply with laws and document that they can effectively minimize the risk of nutrient movement from their operations (Lea-Cox et al., 2001a; Ross et al., 2001b).

Development of a nutrient management planning process

The first challenge in developing a course to train nutrient management planners was to develop a nutrient management process that integrated various cultural factors, i.e., substrate physical and chemical properties, fertilizer application methods and rates, and irrigation water application methods and duration (Lea-Cox et al., 2001a). In considering these factors, a systematic water and nutrient management process was developed that uses a risk assessment approach (Lea-Cox, 2000; Lea-Cox et al., 2001a). The challenge was to formulate a strategy that would allow a grower to capture site-specific information, and write a nutrient management plan that would accurately assess the efficiency of these cultural practices. It was also important to develop a process that incorporated a relatively simple set of metrics that would give similar reporting data for very different growing operations so that plans can be objectively evaluated by the Maryland Department of Agriculture, as the regulatory agency.

The process that resulted not only looks at nutrient movement from a physical point of view, but also captures management data (e.g., irrigation duration) that influence nutrient leaching and runoff from nursery or greenhouse production sites (Lea-Cox and Yeh, 2001). Thus the planning process evaluates both the physical (site and infrastructure) factors that contribute to nutrient runoff, and also measures key variables from substrate, irrigation, and fertilization practices that have the potential to influence N and P runoff from the production site. In consultation with the grower, the planner develops a set of management units that group plant production into the least possible number of units. Favored management units are container size categories, since container size is a variable that most operations use to group plants and track sales.

Container size is important, as it integrates plant density, irrigation efficiency, and fertilizer loading rates per unit area.

A relatively simple risk assessment is then conducted for each management unit, which translates information about water and nutrient management practices into quantitative data. This risk assessment ranks and sums the values for leaching fraction, irrigation interception efficiency, fertilizer source, and N and P application rate, together with site risk assessment factors. This process essentially quantifies the risk of N and P moving from the nursery and identifies high-risk factors to the planner/grower. The final part of the planning process defines risk management options, best management practices, and monitoring procedures that will ensure the effective implementation of the plan (Lea-Cox et al., 2001a; Ross and Teffeau, 2001).

The planner should be able to provide the grower with a range of alternatives for reducing any high-risk practices. However, the decision as to what best management practices are adopted is left to the grower, as the various options are likely to have different economic impacts on the operation. For example, a high-risk situation where high concentrations of soluble fertilizers are applied through overhead sprinklers could be mitigated in a number of ways. Alternatives could include reducing the concentration of fertilizer applied or reducing the frequency and duration of fertigation events. Irrigation duration should be scheduled to minimize leaching of nutrients, and monitoring the electrical conductivity (EC) of the leachate should guide the scheduling of fertilizer applications. Alternatively, the grower could lower the risk of nutrient runoff by substituting a slow-release fertilizer formulation and/or by containing the leaching and runoff in lined containment ponds.

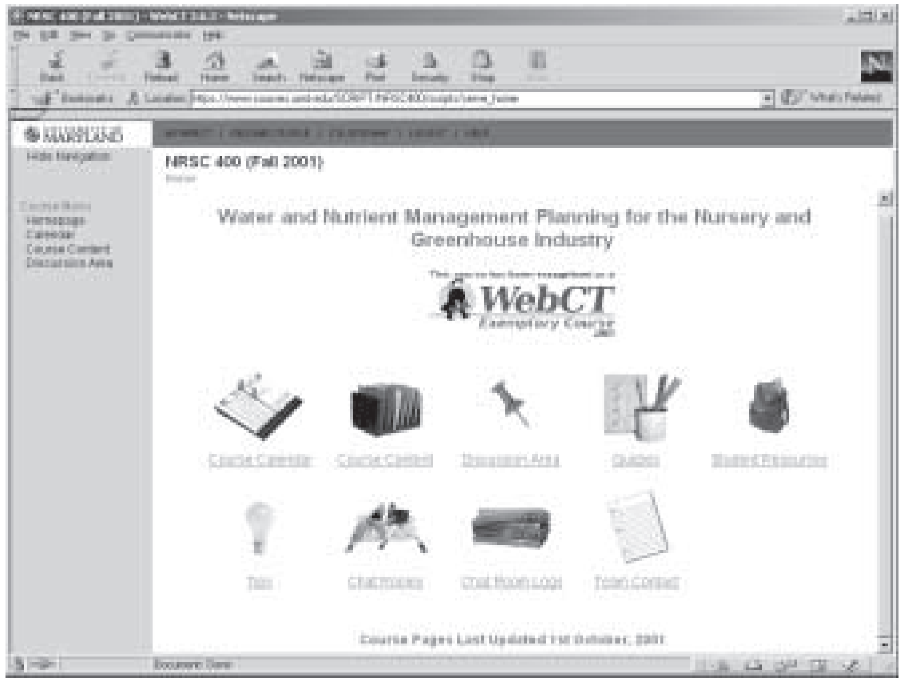

Fig. 1. Homepage of the course, Water and Nutrient Management Planning for the Nursery and Greenhouse Industry, accessed over the Internet with Netscape Navigator version 4.75 (Netscape, Inc., Mountain View, Calif.).

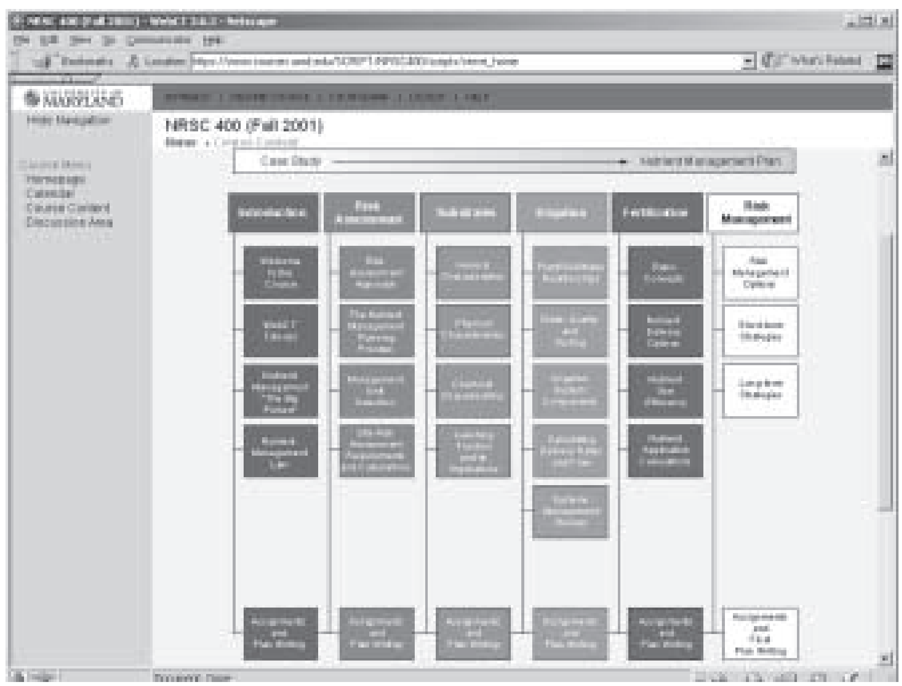

Fig. 2. Color-coded course-content navigation map showing the individual course modules and sections for the course, Water and Nutrient Management Planning for the Nursery and Greenhouse Industry. The top bar indicates the progression of the case-study and assignments over the period of the course.

Training nutrient management planners

Since no state has required mandatory nutrient management plans for nursery or greenhouse operations up until this time, few people have had the incentive to formulate approaches to deal with this kind of regulation. Also, since the environmental risk assessment/risk management concept is relatively new in agriculture, a readily accessible learning environment to teach these principles is necessary. The preparation of these types of nutrient management plans requires the synthesis of knowledge and skills from a number of different subject areas, including soils and soilless substrates, plant nutrition, irrigation, and surface water management, that are then integrated into the water and nutrient management process.

The second challenge we faced

Fig. 3. An example of a course-content page with text, visuals and hyperlinks to short video-clips on the course, Water and Nutrient Management Planning for the Nursery and Greenhouse Industry.

Fig. 4. Break-out groups of teams developing individual nutrient management plans at a typical nursery site visit at the end of each module.

was to develop a course that could be accessed by both resident university students, but also professionals within these industries whenever time was available. After the industry was surveyed (Teffeau et al., 1999), a web-based format was chosen to deliver the course, since nursery and greenhouse professionals are widely dispersed throughout the state, but most often have access to the Internet. WebCT courseware (WebCT, Inc., Lynnfield, Mass.) provides the online learning environment for the course (Lea-Cox et al., 1999). The WebCT courseware is password-protected and housed on a secure server. Registered students can access the course any time and any place convenient to them by logging on to the server through the Internet and by using any type of web browser (Fig. 1). The course consists of six content modules covering the science or subject matter necessary to understand the water and nutrient management planning process (Fig. 2). These six modules are supported and enhanced by text resources, hypertext links to external Websites and resources, photographs, graphic illustrations, powerpoint presentations, and video clips (Fig. 3). Turgeon (1997) foresaw the development of such software, stating "computer-based interactive courseware can be developed to enable students to acquire the entire range of cognitive skills contained in Bloom's taxonomy (Bloom, 1956)." Turgeon (1997) stated that learning objectives should introduce each instructional module that contains both text, visual and auditory information. Each learning module should also contain quizzes and assignments that are designed to synthesize knowledge and comprehension. Practical assignments, perhaps as part of a case-study environment, should lead each learner through a disciplined process of inquiry. Each assignment should be designed to enable students to acquire higher-order cognitive skills, including application, analysis, synthesis and evaluation.

An unusual feature of the course is that we partner growers, consultants, extension professionals and university students, into teams. Each team writes a nutrient management plan for a real nursery or greenhouse (usually the operation of the grower on the team), during the course. By interacting as teams, students not only apply theoretical knowledge from the course, but also capture the experiential knowledge of the various professionals on the team, in situations where teams are faced with solving real-life challenges (Kristof and Satran, 1995). Our role, as faculty, is to facilitate independent learning and collaborative inquiry. The primary intent of the course design process is to target various learning styles as well as the cognitive maturity of each learner. By using a problem-based learning approach, and with guidance from the faculty, learners analyze, synthesize and evaluate information to enable them to create and implement realistic solutions to each case-study.

The course is delivered over a 12- to 16-week period, as the content requires time to assimilate and plan development is often detailed. Based on

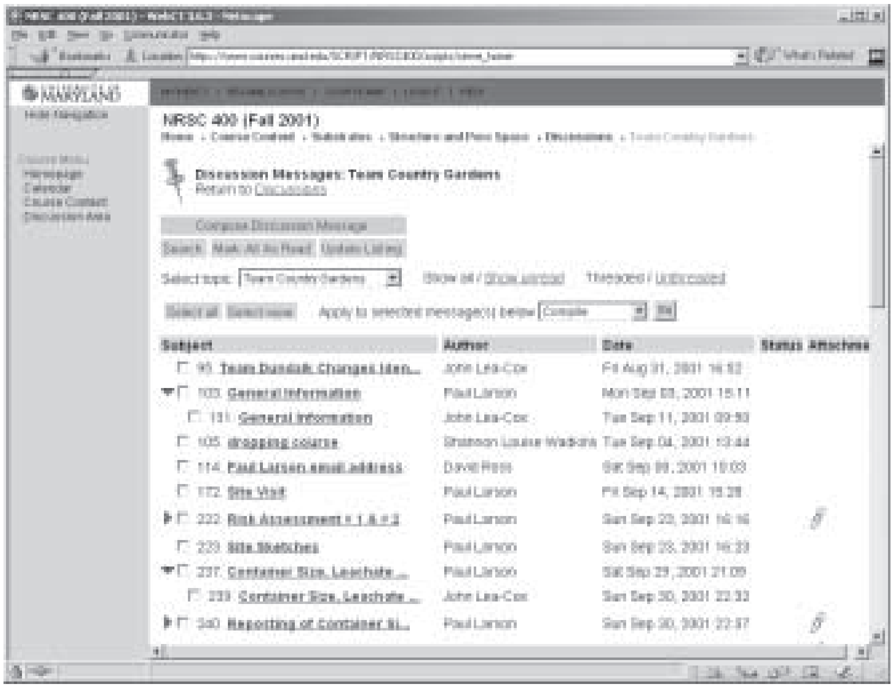

Fig. 5. A threaded asynchronous team discussion area where class participants share files and information for each operation, post assignments and receive constructive feedback from instructors of the course, Water and Nutrient Management Planning for the Nursery and Greenhouse Industry.

a beta-test of the course in 1999, we added five half-day face-to-face meetings at various nursery and greenhouse locations during the course delivered in Fall 2000 and the spring and Fall of 2001. These on-site meetings allow the teams not only to see the physical layout of each operation, but also gives them time to exchange ideas and ask direct questions (Fig. 4). We have found that this motivates individual team members with individual and team assignments and affords us, the instructors, the opportunity to pace the course more effectively. Given the diverse geographical locations and backgrounds of the students enrolled in the course, the use of WebCT allows the students to access the course at any time or at any location convenient to them. This is especially important to industry professionals, as they are not required to come to campus at set class times to receive instructional materials.

This web-based course differs from traditional courses in several ways (Lea-Cox et al., 2001b). It not only relies on traditional teaching techniques using text and illustrations and outside web resources within each module, but also provides an enhanced, interactive learning experience through use of assignments posted to discussion forums, that are linked to a variety of group and individual plan assignments in the course (Angelo and Cross, 1993). The emphasis is on teaching critical thinking skills, which are prerequisites for developing site-specific nutrient management plans. Involving the industry professionals also allows us (the instructors) to capture practical methods to achieve these goals and refine the planning process through critical feedback from end-users.

We use individual and team online discussion areas within the course to post information and files on each operation, exchange ideas, and discuss problems (Fig. 5). The course instructors intensively monitor personal and team discussion forums during the course. By sharing in the development process for different operational plans through postings to each team forum, each course participant has the opportunity to critically assess and learn from the approach taken by other teams (Pallof and Pratt, 1999). Each team conducts an on-site evaluation of the physical layout and operational management of their nursery or greenhouse, conducting measurements of leaching fraction and interception efficiency (Ross et al., 2001b). Team members also gather data on a number of specific crop production practices for each management unit (e.g., fertilization application data). The assignments allow the learners to gain insight into how the objective, empirical measurements they make fit into the risk assessment matrix, which is later used to formulate risk-reduction management strategies. All of this data is then incorporated into the final nutrient management plan. A completed nutrient management plan for the assigned nursery or greenhouse is the final product or exam for the course.

Thus, this process not only gives the grower an assessment of the nutrient runoff potential from the nursery or greenhouse operation, but also gives real insight into the cost-effectiveness of major cultural inputs and decisions in the business. The process can also provide the grower with data on the efficiency of the business and a range of alternatives to improve production and perhaps increase profitability.

Conclusions

By December 2002, all nursery and greenhouse operations in the state of Maryland must have nutrient management plans written and implemented (Maryland Department of Agriculture, 2000). A water and nutrient management planning process is now available, based on risk assessment and best management practices (Lea-Cox et al., 2001a). A web-based course trains industry members and consultants with information and analytical skills that are essential to develop these nutrient management plans. Teams work to assemble and analyze data for a real operation and write the plan during the course. After state certification, these people will write plans and help to educate other growers on better management practices, to help reduce the flow of nutrients into the Chesapeake Bay and other water bodies. In the long term, the environment will benefit as the nursery and greenhouse industries better utilize their water and nutrient resources.

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