

A crop physiology course—level and content¹

F. P. Gardner and R. B. Pearce²

ABSTRACT

Undergraduate courses in crop science have traditionally been presented on a crop or crop-type basis (grain, forage, oil, fiber, etc.) rather than on a conceptual basis (crop physiology). Peer appraisal of a course in crop physiology, proposed on a conceptual basis, was obtained.

In 1977, a questionnaire was sent to crop physiologists in the American Society of Agronomy for their evaluation of the importance of selected topics for a proposed crop physiology course (1 = very important, to 5 = not important). Respondents considered the proposed outline logical. Some topics were ranked as more important than others for a crop physiology course. Major topics such as carbon (1.8), partitioning (1.8), plant stresses (1.9), photosynthesis (2.0), and light (2.0) were viewed as more important for the proposed course than respiration (2.1), growth and development (2.1), harvest physiology (2.1), mineral nutrition (2.2), future challenges (2.3), and growth substances (2.5). Subtopics within a major area varied widely in ranking, i.e., under carbon; canopy characteristics and CO₂ uptake were considered more important than ambient levels, trends, and fertilization with CO₂.

Most institutions surveyed offer courses in crop physiology which are taught primarily at the graduate level. Most respondents felt that a dual level (senior-graduate) course in crop physiology, with a plant physiology course prerequisite, was most desirable as the first crop physiology course.

If the undergraduate curriculum in agronomy is to be based on conceptual courses, we suggest that a course in crop physiology should be included.

Additional index words: Conceptual courses, Crop science, Agronomy courses.

CCOURSE offerings in agronomy or crop science at Land Grant universities have been examined and reported to the A-1 Division of the American Society of Agronomy (ASA)³. In their survey they found the following. (1) Generally, content of undergraduate courses in crop science was organized with emphasis on a crop (i.e., cotton or tobacco production) or a group of related crops (i.e., grain or cereal crops, forage crops, special crops, or "fiber and oil" crops). Except for plant breeding, few courses were organized on a conceptual basis. (2) Crop oriented courses appeared to lead to redundancy due to the commonality of principles

among crops which tended to result in superficial treatment of basic concepts. (3) An introductory course in crop science was offered at most institutions, but the content varied widely, ranging from essentially a beginning botany course to a general course in crop production, often geographically oriented. Mitchell and Gardner³ suggested that key concepts in a body of knowledge could be more effectively learned if subject matter was presented on a conceptual basis. Also, the introductory course in crop science should contain the broad, basic concepts.

Gardner (F. P. Gardner, 1971. A model for derivation and organization of courses. p. 126. *Agron. Abstr.*) suggested that courses in crop science and soil science should embrace key concepts of these respective bodies of knowledge. The introductory course should consist of the families of concepts in the discipline as the basic units of instruction in the introductory course. An individual family or group of related concepts, i.e., the physical properties of soils, could be expanded in breadth and depth for a second-level or derivative (D) course. Member(s) of a family of concepts could be expanded for a course at the third level of complexity (D') if additional expansion for specialization in the subject is desired.

A plan for the organization and offering of courses in crop science, on a conceptual basis, was implemented at Iowa State University in 1964. One derivative course from the introductory course was in the area of physiology and management termed *Crop Growth and Culture*. Dr. Mitchell (1970) published the textbook, *Crop Growth and Culture*, to support this new course. Because this was a major adjustment at the time, traditional patterns seemed to mitigate against titling the course *Crop Physiology* as desired. Mitchell probably titled his book with the same restraint. A course called *Principles of Crop Physiology* is currently taught at Iowa State University for majors in agronomy, with a plant physiology course prerequisite.

This paper deals with developing appropriate content for a course which would be titled *Crop Physiology*. Like Iowa State, Western Illinois University offers an undergraduate-graduate level course in crop physiology

¹Contribution from Dep. of Agric., Western Illinois Univ., McComb, IL 61455 and Agronomy Dep., Iowa State Univ., Ames, IA 50011. Journal Paper No. 48, College of Agriculture, Iowa State Univ.

²Visiting professor and professor of agronomy, Univ. of Florida and Iowa State Univ., respectively.

³R. L. Mitchell and F. P. Gardner. 1963. A new subject matter arrangement for field crop courses. p. 126. *Agron. Abstr.*

titled *Advanced Crop Science*. Mitchell's textbook, *Crop Growth and Culture*, is required.

We desired peer appraisal of content and level of the proposed course, outlined in Table 2. To accomplish this, a questionnaire was sent to crop physiologists in the ASA in August 1977. Responses to a series of questions and the ranking of topics in the course outline as to relative importance were requested.

RESULTS AND DISCUSSION

The percentage return on the questionnaire was about 60% (28/50). Ranking of major topics or the broad subdivisions of the proposed Crop Physiology course is given in Table 1.

Carbon, partitioning, plant stresses, photosynthesis, and light received the highest rating of all major topics (between 1.8 and 2.0). Growth substances received the lowest rating (2.5). Mineral nutrition was ranked 2.2 or "important" with some comments suggesting that mineral nutrition could or should be taught in soil science. Likewise, there were comments suggesting that growth regulation is more applicable to horticulture and/or weed science and could be omitted from Crop Physiology. No respondents suggested that photosynthesis and related areas (light, carbon, respiration, and partitioning of assimilates) be omitted in the proposed course. However, there were numerous comments as to the nature or kind of coverage these topics should receive. Most respondents felt that photosynthesis and related topics should be treated at the plant community level rather than at the cellular level. Several suggested that a plant physiology course should be required as a prerequisite to the proposed crop physiology course. Respondents apparently felt that students should have a background in the biochemical and cellular aspects of plant physiology before enrolling in a course in crop physiology, represented by the proposed outline. Crop scientists could then concern themselves with photosynthesis and other physiological phenomena at the canopy or community level.

Table 2 presents respondent rankings of the sub-tropical components of each major topic. Definitions, meristems, and growth-differentiation subtopics were

Table 1. Topical outline. Peer ratings of topics in a proposed course in Crop Physiology

Ratings†	Topics
2.1	I. Introduction
2.1	II. Growth and development
2.5	III. Growth substances
2.2	IV. Mineral nutrition
2.0	V. Light
1.8	VI. Carbon
1.9	VII. Photosynthesis
2.1	VIII. Respiration
1.8	IX. Partitioning
1.9	X. Stresses
2.1	XI. Harvest physiology
2.3	XII. Future challenges

† 1 = very important, 2 = important, 3 = good to know, 4 = of some value, and 5 = not important.

Table 2. Detailed outline and peer rating of proposed course topics in Crop Physiology

2.1 I. Introduction	2.0 A. Crop Physiology—An emerging science
	1.5 B. Dynamic relationships of growth and yield
	2.9 C. Distinction between crop physiology and plant physiology
2.1 II. Growth and development	
	1.6 A. Definitions
	2.1 B. Cells, tissues, organs, and plants
	2.6 C. Kinetics of growth
	2.7 D. Allometry
	1.7 E. Meristems and related crop development (tillering, branching, rooting)
	2.4 F. Ontogeny and morphogenesis
	2.2 G. Internal and external factors affecting growth
	2.1 H. Differentiation
	2.1 I. Factors affecting differentiation
	1.9 J. Growth-differentiation correlations
2.5 III. Growth substances	
	2.1 A. Classification and terminology
	3.1 B. Classical work and historical
	2.5 C. Auxins and crop responses
	2.4 D. Gibberellins and crop responses
	2.7 E. Kinins and crop responses
	2.8 F. Inhibitors/retardants and crop responses
	2.9 G. Ethylene and other crop substances
	2.8 H. Defoliant and desiccants
	2.5 I. Agricultural applications
	2.1 1. Rooting
	2.3 2. Thinning
	2.5 3. Growth modification
	2.4 4. Fruiting modification
2.2 IV. Mineral nutrition	
	2.1 A. Requirement by plants
	2.1 B. Transport
	2.6 1. Outer and free space
	2.5 2. Active and passive movement
	1.8 3. Movement of organic and inorganic substances in plant tissues
	2.3 C. Metabolism of minerals
	2.6 1. Uses in plant processes
	2.4 2. Biological nitrogen fixation
	2.0 D. Nutrition, crop yield, and quality
	2.0 E. Root growth and development
	1.6 G. Root system architecture as related to growth and yield
2.0 V. Light	
	1.5 A. Energy budget
	1.9 B. Properties of light
	2.3 C. Pigments: Action and absorption spectra
	2.3 D. Control mechanisms—Seed germination, flowering, other
1.8 VI. Carbon	
	2.3 A. Ambient levels and CO ₂ trends
	1.5 B. Carbon sources and availability
	1.5 C. Canopy features and CO ₂ uptake
	1.7 D. Canopy ventilation—Natural and manipulated
	2.2 E. CO ₂ fertilization
1.9 VII. Photosynthesis	
	2.3 A. Light and dark phases: Electron transport
	2.4 B. Energy sinks and Emerson enhancement
	2.3 C. Alternative carboxylation pathways
	1.6 D. Crop canopy—Characteristics and CER
	1.6 1. LAI
	1.6 2. Plant geometry—Leaf angle and orientation
	1.8 3. Optical qualities, extinction
	1.6 E. Crop response to irradiance levels
2.1 VIII. Respiration	
	1.8 A. Mitochondrial
	1.8 B. Photorespiration
	1.6 C. C ₃ /C ₄ characteristics: Anatomical, biochemical, physiological
	2.6 1. Theories of origin
	2.3 2. Variation between and among taxa
	2.3 3. Alternatives for photorespiration tenation

(continued)

Table 2. Continued

1.8 IX. Partitioning
1.6 A. Translocation and partitioning
1.7 B. Harvest fraction and biomass
2.1 C. Yield components
1.6 D. Source-sink relationships
1.7 E. Senescence
2.3 F. Cyclic behavior—Annuals, biennials, perennials
1.9 G. Food reserves and storage organs
1.9 X. Stress and crop responses
1.8 A. Water
1.7 B. Temperature
2.3 C. Atmospheric pollutants
2.1 XI. Harvest physiology
2.0 A. Physiologic maturity and harvest maturity
2.3 B. Black layer and indicators
1.9 C. Harvest schedules, maintenance of food reserves, production and stand survival
2.1 D. Relationship of regrowth of perennials forages to food reserves and basal LAI
2.1 E. Fall management of perennials forages
2.4 F. Seed size and quality
2.3 XII. Future challenges to the student in Crop Physiology

perceived as being more important than kinetics, allometry, and ontogeny. Based on responses received, the latter topics could be omitted, especially if fitting the course into a semester term is a problem. However, from our point of view, the relationship of size of plant parts (allometry) and pattern of development over time (ontogeny) are important in a course on crop physiology.

Growth substances was considered least important of the major topics in the course outline. These ratings reflect an attitude that growth substances should probably be covered in horticulture or weed science courses. However, such a decision seems quite arbitrary to the authors since the use of growth substances on field crops, except as a weed control agent, would probably not be covered in other disciplines.

Subtopics under mineral nutrition received variable ratings (Table 2). Transport was considered important. Energetics and mechanisms of uptake and movement were viewed as less important than transport. Respondents may have assumed that these topics were covered in Plant Physiology or soil science courses. Root system architecture was viewed as important (1.6), the special arrangement of roots and effective surface might have been viewed as analogous to canopy architecture in importance to crop growth.

Subtopics of light-pigments—action and absorption spectra, and control mechanisms—in light responses were viewed as less important. Respondents may have viewed these as duplications of topics in plant physiology. Changes in the ambient level or the upward trend of CO₂ in recent years were not perceived as important as course topics nor was CO₂ fertilization (Table 2).

Respondents considered respiration important, but slightly less so than photosynthesis. Assimilate requirements for growth and maintenance and losses due to photorespiration and dark respiration were of interest. Photorespiration and dark respiration need to be under-

stood at the cellular level to understand how they influence crop development and yield. Subtopics under partitioning of assimilates were ranked high except for life cycle and related growth habits. Partitioning of mineral elements should also be included.

Plant stresses were considered important; however, there was less interest in stresses from pollutants. Harvest physiology was rated important except for seed size and size effects on seedling growth. Seed size and seedling growth may have received a higher rating if it had been listed in a better context, probably under growth and development. The extensive and excellent work on seed physiology and relationships to crop growth makes it worthy of inclusion in crop physiology. Respondents reflected little enthusiasm for the future challenges topic.

Twenty respondents replied that their university offered a course(s) in crop physiology (Table 3). The indication was that most or practically all offerings were at the graduate level. However, 56% (17/30) replied that the proposed outline should be a senior-graduate or dual-level course (Table 4). This response leaves some confusion. (1) Is the proposed course less sophisticated than the course(s) now offered (most at the graduate level)? (2) Do respondents feel there is a need for a dual-level course in the subject matter despite present offerings? (3) Do the respondents feel that undergraduate students in agronomy should take a crop physiology course taught at the undergraduate level? The outline of the proposed course (Tables 1 and 2) was developed with questions (2) and (3) in mind.

Apparently, some respondents classified all plant biochemistry and plant physiology course offerings at their institution as crop physiology. Some stated three or more courses in crop physiology are offered, all at the graduate level. We feel that crop physiology is a body of knowledge in its own right and disagree with a classification of plant physiology and plant biochemis-

Table 3. Responses to selected questions pertaining to a proposed course in Crop Physiology

Question	No. and responses
Does your institution offer a course in Crop Physiology?	20 Yes* 2 No
At what level should course (Table 2) be offered?	3 Junior-Senior 4 Senior 17 Senior-Graduate 5 Graduate 1 None
Is organization of course outline logical and would it build on student progress in his discipline?	20 Logical 1 Not logical

Table 4. Additional comments

Needs more emphasis on physical environment and community behavior.
Why separate light and carbon from photosynthesis?
All topics important—can't rank them.
Outline too broad for single course.
Not enough emphasis on crop physiology as compared to plant physiology.
Not enough emphasis on nitrogen, especially biological nitrogen.
Not enough emphasis on ecology of crop production.
Should have plant physiology as prerequisite.
Partitioning would more logically fit under growth and development.

try as crop physiology. A majority of respondents believe that the outline (Table 2) is logical and that it builds on progress of the student.

The proposed course would be the first crop physiology course the student would take with plant physiology as a prerequisite. We agree with many comments offered by respondents (Table 4) to the extent that the proposed outline could be changed in several ways. The topics light and carbon could just as well be subtopics under photosynthesis. Partitioning is an integral part of vegetative and fruit growth and development, and could be a subtopic of growth and development, especially since partitioning involves both minerals and carbon assimilates.

SUMMARY AND CONCLUSIONS

A questionnaire was sent to crop physiologists in ASA to obtain their evaluation of appropriateness of content, context, and level for a course in crop physiology. Responses indicated that most Land Grant universities offer a course or courses in crop physiology (prin-

cipally at the graduate level) and that the outline we proposed should be a dual, senior-graduate level course. Many respondents would require plant physiology as a prerequisite although this was not a specific question in the survey. Write-in comments indicated that the course should emphasize physiology of the crop community rather than cellular metabolism (the emphasis in plant physiology). The respondents suggested that the greatest emphasis should be on photosynthesis in the crop community and associated phenomena. Respondents were less impressed with growth regulation as a topic. Many felt that the coverage (as outlined in Table 2) for a single course is too broad. The authors hold that a survey course in crop physiology is needed just as survey courses are needed in other bodies of knowledge, i.e., soil science or plant breeding. A survey course is intrinsically broad. Crop Physiology is no exception.

LITERATURE CITED

1. Mitchell, R. L. 1970. Crop growth and culture. Iowa State University Press. Ames.