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ABSTRACT

The unit was developed as a guide for use by teachers in planning and conducting adult classes in horticulture. The target audience is adults employed in agriculture in Kentucky. Because of the diversity in age, expertise, and experience levels of class members and instructors, the unit was designed to cover the basic areas of greenhouse management. Seven lessons have been included which may be modified or expanded to suit each particular course. Lessons are in outline form with the major headings of objective, problem and analysis, content, and suggestions for teaching the lesson. Supplementary materials in the form of illustrations and charts are provided. Appended are unit planning forms and a unit evaluation instrument. (LJ)

GREENHOUSE MANAGEMENT

An Instructional Unit for Teachers of Adult
Vocational Education in Agriculture

Developed by:

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1972

FOREWORD

Mr. Irvin Ashlock, teacher of vocational agriculture at East Hardin High School, brings to this publication 24 years of teaching experience--all of which included teaching young and/or adult farmers and one year of work with adults in horticulture. The greenhouse facilities at East Hardin which were developed under his leadership include a 28 X 54 foot fiberglass greenhouse, a 16 X 40 foot greenhouse and two smaller houses. Each year these houses produce a market value of $4500 in tomatoes, lettuce, flowers and shrubs. Mr. Ashlock developed an extensive high school greenhouse program at East Hardin including the initiation of a horticulture class for disadvantaged students. He holds the B.S. degree from Western Kentucky University and an M.S. degree plus 21 hours in horticulture from the University of Kentucky. He is active in numerous community service and educational activities, including his second term as President of the Hardin County Education Association.

This adult horticulture course is a result of the following sequence of actions:

1) The State Advisory Committee, made up of agriculture teachers, State staff, and teacher educators from throughout Kentucky, was organized to determine needs and program direction for adult work in agriculture for the State. A major outcome of the first meeting in September, 1971, was a recommendation that more instructional materials that are specifically designed for teaching adults in agriculture be developed and distributed to teachers.

2) Subsequently, a proposal to involve experienced teachers of adults in material development was written by Dr. Maynard Iverson of the University of Kentucky and submitted for State funding. In January, 1972, a two-year, $15,000 grant was made through the Supporting Services Division, Bureau of Vocational Education, State Department of Education.

3) Six teachers were selected to produce units in the diverse areas of need during 1972. Mr. Ashlock's unit, "Greenhouse Management" is a product of that project.

This publication, along with future materials developed specifically for the teaching of adults employed in agriculture in Kentucky, should improve the teaching of adult classes in agriculture and stimulate the initiation of additional classes.

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ACKNOWLEDGEMENT

We are grateful to the following people for their contributions in completing the unit: Mr. Ray Gilmore, artist, Curriculum Development Center, University of Kentucky; Mrs. Anne Mills, Mrs. Joann Smith and Mrs. Mitzi Iverson, typists, University of Kentucky; Dr. Frank A. Pattie, Professor Emeritus, University of Kentucky; the many writers whose materials were utilized as references in the unit, and especially to Dr. C. R. Roberts, Extension Professor of Horticulture, University of Kentucky, whose assistance with the preliminary outline, detailed proof-reading, and suggestions for improvement greatly enhanced the usefulness of the publication.

CONTENTS

SUGGESTIONS FOR USING THE UNIT

This unit was developed as a guide for use by teachers in planning and conducting adult classes in Horticulture. Because of the diversity in age, expertise, and experience levels of class members and instructors, the unit was designed to cover the basic areas of greenhouse management. Therefore, teachers should adapt those portions of the unit that are suited to their particular situation. Seven lessons have been included, but the unit may be expanded to more topics or utilized in diversified courses for shorter periods of instruction. It may be helpful to involve class members at the organizational meeting in the selection of lessons and activities. Planning forms to assist in this process are found in the appendix.

The format used was designed to assist teachers in utilizing problem-solving and the discussion method. A teaching procedure that has been used successfully is as follows: Step 1: The teacher lists the topic (problem and analysis) on the chalkboard. Step 2: He then sets the stage for discussion with introductory facts, ideas, or comments, using items from the section on "developing the situation." Step 3: The teacher calls on the class to give their experiences, ideas, and knowledge concerning the subject. The discussion is supplemented with handouts, transparencies, models, or other inputs gathered by the teacher beforehand to help solve the problem under consideration. Resource people or films may also be used here as sources of information. (Transparency and handout masters, which may be reproduced locally, are found at the end of each lesson in the unit.) Step 4: When the facts have been brought out and a good discussion has taken place, the teacher leads the group to appropriate conclusions. These summary statements are written on the chalkboard and, in some cases, are typed up and distributed as handouts at the next meeting. Some instructors will utilize devices such as panels, exhibits, and tours to reinforce the conclusions reached. Several suggestions for supplementary enrichment activities are listed in each lesson of this unit.

Teachers may want to utilize the wealth of local and state resources to supplement their teaching -- greenhouse operators, cooperative extension personnel, suppliers and others will undoubtedly be pleased to serve as resource people, furnish samples, give demonstrations, conduct tours, arrange for films and assist with other activities appropriate to the success of the course.

Each teacher using the unit is asked to complete and return the evaluation questionnaire found in the Appendix. These ratings and suggestions will be used to improve this unit as well as others developed in the future.

Our best wishes for a successful adult program.

Irvin H. Ashlock
Development Consultant

Maynard J. Iverson
Project Director

UNIT OBJECTIVES

Major objective:

To develop the effective abilities of present and prospective greenhouse operators to profitably manage the various phases of a greenhouse business.

Lesson objectives:

1. To develop the effective ability of operators to determine the potentials of a greenhouse operation for expanded income.
2. To develop the effective ability of managers to select a greenhouse structure.
3. To develop the effective ability of operators to control environmental growing conditions inside a greenhouse.
4. To develop the effective ability of operators to prepare good greenhouse growing media.
5. To develop the effective ability of a beginning greenhouse operator to propagate plants.
6. To develop the effective ability of a beginning or experienced greenhouse operator to use plant growth stimulators (fertilizer and hormones) to produce a quality product.
7. To develop the effective ability of greenhouse managers to control greenhouse pests (insects and diseases).

UNIT REFERENCES

Books

Ball Red Book. (George J. Ball, Inc., West Chicago, Illinois).

Flower and Plant Production in the Greenhouse by Kennard S. Nelson (The Interstate Printers and Publishers, Danville, Ill.) 1966.

Greenhouse Crop Production. (Department of Agricultural Education, College of Agriculture, Agricultural Experiment Station, University Park, Pennsylvania) 1968.

Plant Propagation Principles and Practices by Hudson T. Hartman and Dale E. Kester (Prentice-Hall, Inc., Englewood Cliffs, New Jersey) 1968.

Other Publications

Ball Catalog (George J. Ball, Inc., West Chicago, Illinois).

Farm Planning Manual for Kentucky Farmers by Allan and Browning (Department of Agricultural Economics, University of Kentucky) 1970.

Proceedings, Kentucky Greenhouse Flower and Vegetable Grower Conference, 1972.

The Greenhouse Worker by Charles Urbanic (Curriculum Materials Service, The Ohio State University, Columbus, Ohio).

Magazines/Newsletters

Geiger News (E. C. Geiger, Box 285, Harleysville, Pennsylvania) February, March and April, 1972.

Green Thumb (Department of Horticulture, University of Kentucky) December, 1970; September, 1971; and January through June, 1972.

Grower Talks (Geo. Ball, Inc.,) January through September, 1972.

Jed's Jottings (Jeduah Floral Company) September, 1971, through September, 1972.

Kentucky Agricultural Engineer (Department of Agricultural Engineering, University of Kentucky) January, February, and March, 1965.

Kentucky Vegetable Growers Newsletter (Department of Horticulture, College of Agriculture, University of Kentucky) November, 1968; February and December, 1970; October, 1971.

Cooperative Extension Publications (Kentucky)

"Estimating Greenhouse Heating and Ventilation Requirements" by Walker and Duncan (soon to be published).

Greenhouse Consturction Cost and Production Practices, Misc. 352.

"Greenhouse Coverings" by Duncan and Walker (soon to be published).

Greenhouse Location Orientation by C. A. Duncan and J. N. Walker, Misc. Bulletin 397.

"Greenhouse Structures" (soon to be published).

Preservation Treatment of Greenhouse Wood, by Walker and Duncan.

Catalogs

Brighton Horticultural Supplies, Brighton By-Products Co., Inc., P. O. Box 23, New Brighton, Pennsylvania 15066.)

Catalog. (E. C. Geiger, Box 285, Harleysville, Pennsylvania 19438.)

Catalog. (Ickes-Brown Glasshouses, P. O. Box 147, Deerfield, Illinois 60015.) $4.50.

Catalog. (Jeduah Floral Co., P. O. Box 1917, Columbus, Ohio 43216.)

Catalog. (National Greenhouse Co., Pana, Illinois 62557.)

Quonset Greenhouses, (X. S. Smith, Inc., Drawer X, Red Bank, New Jersey 07701.)

Lesson 1

ESTABLISHING A GREENHOUSE BUSINESS

Objective -- To develop the effective ability of operators to determine the potentials of a greenhouse operation for expanded income.

Problem and Analysis -- Should we establish a greenhouse operation?

-Trends in horticulture sales
-Prospective outlook in the community
-Where plants are produced
-Capital required
-Labor and management required

Content

I. Trends in horticulture sales.

A. Overall sales in all types of greenhouse-produced plants are on the increase.

B. Type of production.
1. Bedding plants, vegetable transplants, cut flowers, vegetable production and pot plant production probably occupy most of the greenhouse space.
2. Shrubs (evergreen and deciduous) are propogated in the greenhouse. Marketing trends for shrubs produced in containers are also pointed upward.

C. Statistical evidence is lacking in the areas of many greenhouse crops.
1. Best available facts on bedding plants sales are as follows:
a. Trends in bedding plant sales (U.S.):
1949 -- $15 million annual sales rate.
1959 -- $32.8 million.
1972 -- Estimate $60 million.
1982 -- Estimate $120 million.
b. Growth rate is based on these things:
-Gardening relieves pressure of fast-paced modern living.
-More leisure time.
2. Production of cut flowers is not increasing appreciably.

Sales of Cut Flowers in Dollars*

Plant	1970	1971
Roses	54,000,000	54,600,000
Carnations	47,600,000	46,300,000
Mums Standards	26,900,000	27,500,000
Mums Pompons	26,600,000	29,200,000
Gladiolas	18,700,000	19,000,000
Pot Mums	24,500,000	26,800,000

*SOURCE: Grower Talks

II. Prospective outlook in the community.

A. Surveys will have to be conducted by the grower or prospective grower.

B. Many chain stores located in local communities may buy locally.

C. Observe the overall economic trends in your community; higher incomes lead to more dollars spent for horticulture products.

D. Chain stores are beginning to handle cut flowers.

E. In 1972, general merchandise and variety store garden sales are expected to push over the $2 billion mark.

F. In 1972, growers planned to increase the top six plants:
1. Impatiens.
2. Geraniums.
3. Petunias.
4. Tomatoes.
5. Marigolds.
6. Begonias.

G. Look closely for specialty crops that might succeed in your area.

III. Where plants are produced.

A. Presently Kentucky is one of the states whose horticultural products are not covered by the Statistical Reporting Service.

B. It is difficult to secure information concerning production in Kentucky; growers will need to make a survey.

C. The U.S.D.A. Statistical Reporting Service indicates that gross wholesale value of sales in 1968 shows that out of 23 states, California, Pennsylvania, Ohio, New York, Florida and Massachusetts are the leading states in the production of chrysanthemums, roses, carnations and foliage plants; California, Pennsylvania, New York and Ohio are the leading states in greenhouse production.

IV. Capital required.

A. (Refer to the lessons which follow.)

B. Generally, decisions will need to be made about the following:
1. Kind of production planned.
2. Greenhouse facility.
3. Heating and ventilating equipment.
4. Other general equipment.

V. Labor and management required.

A. Management is the most important factor -- it involves both skill and art.

B. The operator must be willing to devote time and effort to study and learning.

C. In determining labor requirements consider:
1. Full-time or seasonal production.
2. Peak periods of sales, special days, and holidays should be taken into account.
3. Amount of family labor available and unused family labor are important factors.
4. If you plan to fit a greenhouse operation in with other farm work.

D. Greenhouse jobs must be carried out on a rigid time schedule.

E. Refer to the other lessons for specific data.

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Contribution by the teacher (NOTE: the teacher should not feel that he must sell greenhouse production to his students).
1. According to the best records, most production trends in greenhouse produced crops are increasing.
2. According to the best sources, Kentucky offers a potential for expanded income through greenhouse operations.

3. Greenhouse operations require considerable skill and knowledge to be successful.
4. Potential operators should make use of all possible informational sources in making decisions.

B. Things to be brought out by class members.
1. Their interest in greenhouse production.
2. Knowledge of the extent of plant sales in the areas.
3. Opinions about greenhouse production.

II. Conclusions

A. There is a potential for greater income from greenhouse produced crops in Kentucky.

B. Top management skill is needed to be successful with a greenhouse operation.

C. Management skill can be learned if the producer is willing to devote time and effort.

D. Producers or potential producers should use all means at their disposal to make good decisions as to crops having the greatest income potential.

E. Use all means to determine facilities to construct.

F. Surveys of crop possibilities should be made to determine the potential locally.

G. It is not necessary to have the experience of two or three generations in family greenhouse work to be successful.

III. Enrichment Activities

A. Use any horticultural experts in the area.

B. Briefly go through some things which will help in decision making.

C. Visit commercially operated greenhouses.

D. Visit the University of Kentucky Horticulture Department.

E. Visit Eastern Kentucky University Agriculture Department.

F. Visit high school-operated greenhouses.

IV. Suggested Teaching Materials

A. References for Lesson 1
   1. Flower and Plant Production in the Greenhouse, pp. 3-15.
   2. Proceedings, Kentucky Greenhouse Flower and Vegetable Growers' Conference, pp. 74-76.
   3. The Greenhouse Worker, pp. 2-5.
   4. Grower Talks:
      February, 1972, pp. 9-12.
      March, 1972, pp. 5-7.
      June, 1972, pp. 9-15.
      July, 1972, pp. 1-11.
      August, 1972, pp. 16-17.

B. Resource Personnel
   1. Consult local sources.
   2. Cooperative Extension Planning Specialists.
   3. For specific personnel see Vo-Ag Directory of Resource People in Kentucky.

C. Audio-visuals
   1. Masters*
      -1 Greenhouse Budget
      -2 The Commercial Greenhouse Industry

*Masters are keyed to units and lessons, and are numbered consecutively. The code number appears in the lower right hand corner. Master "Adult 101-1-1" indicates: adult unit number 101, lesson 1, item 1.

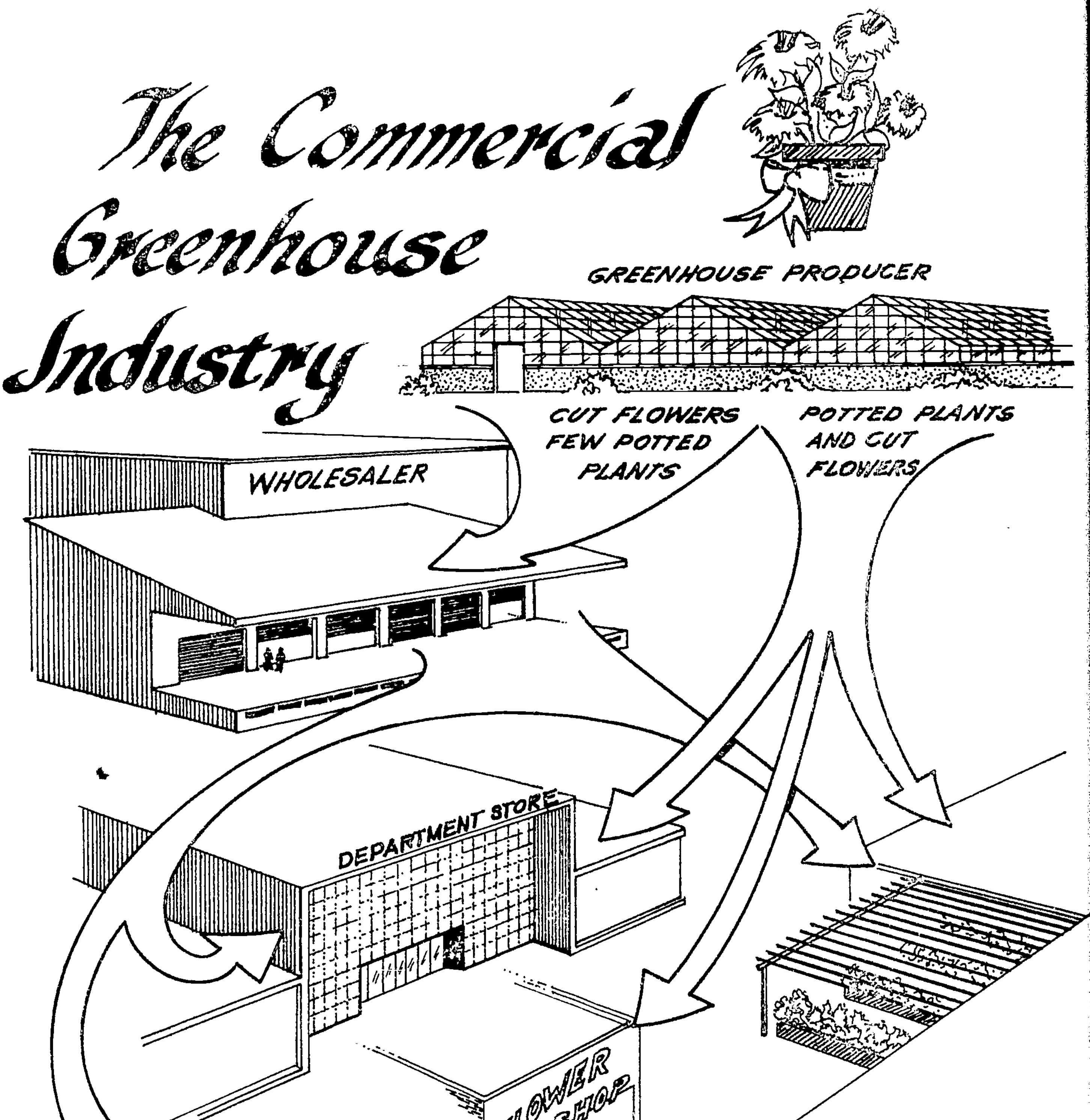
Greenhouse Budget

	Bibb Lettuce and Vegetable Plants (10,000 sq.ft.)		Tomatoes (12,000 sq.ft.)
Expected Returns,	17,000# Lettuce @ 30¢ = $5,100.00		(Two crops
	1700 doz. Tomatoes @ 60¢ = $1,020.00		55,800# @ 30¢
	8,000 doz. Cabbage @ 15¢ = $1,200.00		
	1700 doz. Pepper @ 30¢ = 510.00		
Total	$7,830.00		$16,740.00
Cost Items			
Cash Costs			
Fertilizer and Lime	$ 115.00		$ 225.00
Seed and Mulch	250.00		75.00
Machine operation, Power and Fuel	1,175.00		1,900.00
Chemicals	75.00		60.00
Containers	800.00		800.00
Marketing and Miscellaneous	135.00		3,450.00
Total	$2,550.00		$6,510.00
Overhead Costs			
Depreciation (Building, Machinery, and Equipment)	$1,550.00		$1,880.00
Interest (Building, Machinery, and Equipment)	620.00		750.00
Interest (Land)	25.00		25.00
Taxes	560.00		675.00
Total	$2,755.00		$3,330.00
Labor, 980 hours	$1,470.00	(3750 hrs.)	$5,625.00
Total All Costs	$6,775.00		$15,465.00
Capital Investment			
Land and Grading	500.00		$ 500.00
Machinery and Equipment	500.00		800.00
Structure	15,000.00		18,800.00
Total	$16,000.00		$19,300.00

Source: Farm Planning Manual for Kentucky Farmers, p. 53.

Adult 101-1-1

The Commercial Greenhouse Industry



Lesson 2

SELECTING GREENHOUSE STRUCTURES

Objective -- To develop the effective ability of class members to select a greenhouse structure.

Problem and Analysis -- What type of greenhouse structure should we select?

-Purpose of structure
-Structural design
-Materials to be used for framework
-Types of covering to be used

Content

I. Determining uses to be made of structures.

A. Basic considerations.
1. Generally a greenhouse provides an artificial environmental situation desirable for good plant growth.
2. Not all plants require the same conditions.
3. Decisions must be made as to how long the greenhouse will be operated.
4. Consider the kind of markets available in your area.
5. Decisions must be made as to the kind of structure important for the success of the program.
6. Long range outlook regarding demand for horticultural products.

B. Consideration of production schedule alternatives:
1. Year-round operation.
2. Late winter and spring operation.
3. Fall, winter, and spring operation.
4. The type of schedule will determine the need for permanent, semi-permanent or temporary cover.
5. Type of covering will, in turn, dictate the framework needed.

II. Characteristics of structural design.

A. Factors in selecting design:
1. Location.

a. Orient and locate the house for maximum sunlight. In southern latitudes, the ridge should run north-south and in northern latitudes east-west.
b. Place in an area sheltered from northerly and north-westerly high winds if possible.
c. Locate on a deep, good soil which is well drained and where surface water does not run into the house.
d. Avoid sloping beds or floors in the greenhouse. Locate the greenhouse near adequate and reliable sources of utilities--electricity, water and gas.
e. Provide good access roads, parking, and turn-around area.
f. Position headhouses or supporting facilities on the north side.
g. Arrange initial construction so that the range can be expanded. Most successful ranges are expanded several times after the first house or small range area is constructed.
h. No objects taller than 10 feet should be within 27 feet of the greenhouse in either the east, west, or south sides. Even objects this tall will cast long shadows in the early morning when the sun is particularly low in the sky.
i. The structure must be attractive if it is to be located adjacent to a retail outlet.
j. Buildings should blend in well with surroundings.
k. Large ranges require special consideration.

B. Structural design.
1. Gable houses are the choice of many greenhouse growers.
   a. Building materials can be galvanized pipe, steel, aluminum or wood.
   b. This design can be for a permanent structure or used temporarily.
   c. It is versatile in size.
2. Quonset.
   a. This style is gaining in popularity, particularly among growers who are enclosing with temporary cover.
   b. Construction may be of thin-walled conduit, galvanized steel pipe or solid steel rods.
   c. This may be operated as field greenhouses, cool greenhouses or for spring production of bedding plants.
   d. In some areas, nurserymen cover the quonset with polyethylene in winter and shade cloth in the summer.

3. Ridge and furrow.
   a. This design is primarily for greenhouse ranges (large operations).
   b. The frame can be of metal or wood.
   c. Usually, glass is used to cover the structure, but plastic film or fiberglass is also used.
   d. Small, self-supporting gables characterize this design.
4. Self-supporting bubble.
   a. Construction is of polyethylene film.
   b. The bubble is inflated by fans which maintain constant pressure.
   c. Some larger models use some cable supports.
   d. This design is primarily experimental at this date.
5. Gothic.
   a. Many small gothic houses are used as hobby houses.
   b. The most popular construction material is redwood; metal is also used (aluminum).
   c. Gothic design offers a unique shape for certain landscape designs.
   d. Glass, fiberglass and polyethylene film are used for covering most gothic houses.
6. "A" Frame.
   a. Primarily, A-frames are for hobby house use.
   b. Frame construction is mostly wood.
   c. The frame is covered with glass, fiberglass or film.

(NOTE: Plans are available from U.K. Extension Service for wood-constructed ridge-and-furrow, gables and thin-walled conduit quonset structures.)

III. Deciding on structural material.

A. Prerequisites:
   1. Soundness of structure: whether "twisting" is permitted, etc.
   2. Materials available in the area.
   3. Availability of skilled labor for construction.
   4. Personal competence in construction.
   5. Amount of capital required.

B. Structural material options:
   1. Aluminum. Major characteristics are:
      a. It is permanent.
      b. Minimum upkeep is required.
      c. Pre-formed parts are necessary.
      d. Skilled labor is needed to erect aluminum structures.
      e. Aluminum is often used as framework for glass.
      f. It comes prepared as a package deal.

g. Painting may be needed to improve water turn-off in the glazing process.

2. Galvanized pipe.
   a. Pipe is used in constructing pole-type structures to accommodate fiberglass panels.
   b. Builders should investigate possibilities of securing used pipe.
   c. Pipe must be painted and maintained.
   d. Pipe can be bent and used to construct quonset-type houses.
   e. Some skilled labor is required to erect pipe frames.
   f. "Packaged" greenhouses are available.
   g. These are considered permanent structures.
3. Steel.
   a. Steel is used in round, solid-bar form to construct quonset houses.
   b. Other forms are used in pipe construction.
   c. Steel must be painted and maintained.
4. Wood.
   a. Satisfactory permanent structures can be built from wood.
   b. Wood for greenhouse use must be either specially selected or treated.
      (1) Select decay-resistant wood for 5-10 times longer service at little extra cost.
      (2) Use non-resistant wood treated with chemical preservatives, but consider toxicity to plants as well as effectiveness.
         (a) Oil born preservatives include creosote and pentachorophenol (penta); both are toxic and therefore are not recommended.
         (b) Water-borne salt type preservatives are slightly toxic if not weathered before use.
         (c) Paint is <u>not</u> a substitute for preservatives; it only protects the surface and improves light reflection and appearance.
         (d) Method of treatment affects life of wood.
         (e) Consider the overall effect on greenhouse use.
   c. Labor to construct wooden structures is more readily available.
   d. Materials from the home farm may be used, provided they are treated.
   e. Light emission may be reduced due to shadows from the superstructure, especially on wide construction.

f. Plans are available from U.K. Extension Center.
5. Plastic Bubble.
   a. This type is experimental at present.
   b. Contact manufacturers for further information.

IV. Types of covering:

A. Polyethylene (Regular and U.V.).
1. Polyethylene is the lowest cost covering; regular costs .7 to 1 cent per sq. ft.; UV runs 1 1/2 to 2 cents per sq. ft.
2. Widely available, some manufacturers report recently they have stopped production of this product for greenhouse use. (Thus, be cautious of buying any product of unknown quality for greenhouse use.)
3. It has a relatively short life in the sun: 9 to 11 months for regular, 12 to 18 months for UV.
4. It splits more easily at the folds. Use unfolded material or lay material flat for maximum life.
5. Polyethylene transmits approximately 85 to 88 percent of the solar energy available at the earth's surface.
6. It transmits all wavelengths of the spectra required for plant growth.
7. It transmits the wavelengths of thermal radiation, thus allowing the house to cool more rapidly at night.
8. The strength of new 4 mil and 6 mil film is one to two times that of 1/8 inch standard glass.
9. This material permits double-layer covering which results in 35 to 40 percent reduction on heat loss, reduced condensation, and only 8 to 10 percent reduction in light due to the second (clean) layer.
10. A "tighter" house with less air leakage results; this causes somewhat higher inside humidity conditions.
11. Film is most useful for low-cost temporary or seasonal coverings.
12. Polyethylene film reinforced with synthetic fibers is also available at a cost four to five times that of regular film, but generally this material is not used for greenhouses.
13. Double-layer covering on top side of the structure, with a centrifugal fan developing pressure between the two layers in a way to reduce labor and installation costs. Life is equal or better than conventional installation methods.

B. Vinyls.
1. UV forms are more resistant to sunlight than polyethylene; they last two to five years.
2. Cost is 6 to 10 cents per sq. ft. for 8 to 12 mil thickness.

3. Made in narrow widths (5 to 7 feet), vinyls must be heat-seamed together by the manufacturer for wider widths.
4. The material is soft and pliable.
5. The materials tend to be electrostatic, resulting in dust and dirt being attracted to them. This necessitates regular cleaning.

C. Polyvinylflouride.
   1. The Tedlar* film has proven to have excellent weatherability but is too costly to compete with existing films as a covering. It is now being used as a surface coating which is molecularly bonded to fiberglass panels to improve their weatherability.

D. Rigid plastics.
   1. Polyvinylchloride (PVC) is transparent to solar radiation but the unprotected polymer darkens during weathering by the influence of UV rays. Most of the materials have not been suitable for more than two to four years as a greenhouse covering; therefore, they are no longer advised for greenhouse use.
   2. Plexiglass**.
      a. An acrylic plastic, plexiglass has been available for many years but has not been widely used as a greenhouse covering due to high cost. (An exception is their use for special climatic or conservatory type facilities.)
      b. It is much more resistant to impact than glass.
      c. It transmits approximately 90-92 percent of available sunlight and is available in UV transmitting and UV absorbing types.
      d. Plexiglass has long life, and weathering resistance comparable to glass.
      e. Softer than glass, it is easily scratched and is sensitive to some solvents.
      f. Cost is appreciably more than glass and other possible covering materials.
      g. It is flexible enough to be used as curved panels in glasshouses.
      h. It is strong enough to resist snow and ice loads near gutters of connected houses.
      i. Plexiglass expands and contracts greatly with temperature changes and should not be directly nailed or screwed down, but held under a cover strip with soft mastic sealer to allow movement.

*Registered by E.I. DuPont De Nemours and Company, Wilmington, Delaware, 19898.

**Registered by Rohm and Haas Company, Philadelphia, Penn.

3. Fiberglass reinforced rigid plastics (FRP).
   a. Many brands of the basic polyester resin reinforced with fiberglass are available in flat and corrugated forms. Corrugations add strength.
   b. It is made in "weights" from 4 to 8 ounces per sq. ft., widths up to 51 1/2 inches (48 inch coverage) and lengths pre-cut up to 30 or more feet (special order). Use minimum number of joints and laps to reduce chances of dust and dirt accumulation between panels and also air/water leakage. Use proper clear sealer on laps for tightness.
   c. Cost ranges from 20 to 30 cents per sq. ft. for 4 to 5 oz. panels, 30 to 35 cents for 6 oz. panels, and 45-55 cents for Tedlar coated panels. Culls (Grade B) and assorted lengths are sometimes as low as 15 cents per sq. ft., but be cautious of the quality of these products.
   d. FRP is two to four times more resistant to impact and lateral loading than glass. Crazing (not shattering) usually results from impact, but this crazing has no harmful effect unless the panel surface is cracked or broken.
   e. The polyester of the panels burns freely and rapidly; entire houses have burned in approximately 10 minutes. Flame retardants and good weatherability have not been successfully used together. Insurance on fiberglass is not easily obtainable.
   f. Clear or "frosted" panels of greenhouse-quality material transmits approximately 78 to 90 percent of available light when new. Non-greenhouse formulations, especially colored panels, should be avoided.
   g. Panels with 15 percent acrylic additive have proven more durable than straight polyester formulations.
   h. Acrylic modified polyester panels (with the exception of those having a Tedlar coating) need cleaning at least annually, and generally resurfacing with an acrylic liquid sealer every 4 to 5 years to restore weathered surfaces to near-new transmission and surface condition. The durability of the sealer coat is questionable and undergoing more study at present.
   i. Some manufacturer's guarantees are rather nebulous. Until accurate evaluation procedures and quality standards are established, judge a product more on its performance and company reputation than on its "guarantee".
   j. Proper attachment to the structure and sealing/fastening of lapped joints is essential for

resistance to wind forces. (Use fasteners every 8 to 12 inches on ends and sides, or per manufacturers specifications.)

4. Regular glass.
   a. Single strength and small panes are not used much on newer designs and constructions. Replacement of panes in existing houses should be double-strength for more resistance to breakage.
5. Tempered glass.
   a. Tempered glass is two or three times stronger than regular glass.
   b. Frosted or "hammered" types are available for better light diffusion, reduced shadows, and non-see-through properties.
   c. Larger pane sizes reduce structural members, hence creating less shadow.
   d. This covering requires special structural members and glazing methods to give water-tight and air-tight construction.

E. Consider again:
   1. Length of time of operation.
   2. Plants to be produced.
   3. Production methods.
   4. Available financing. (See costs in tables 5 and 6.)
   5. Resistance to weathering. (See chart: "Comparison of Light Emissions...".)

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Things to be brought out by the teacher:
   1. A greenhouse operator should decide on what kind of production he wants before he decides on the structure.
   2. The structure has a direct relationship on the success of the operation.
   3. Decisions of which structure to use should be based on production plans, personal ability and capital requirements.
   4. The expectant operator should make tentative short and long range plans.
   5. If you are close to a suburban area you should consider the possibility that expansion of the city, streets or super-highways may overtake your operation.
   6. There is considerable variance in the cost per foot for greenhouse construction.

B. Things to be brought out by class members:
   1. Interest in greenhouse structures.

2. Comments about houses they have seen.
3. Operators in the class can broaden class concepts through sharing their personal experiences with structures.

II. Conclusions

A. There are structures which will fill the needs of all growers.

B. Operators need to determine what design and materials will best fit their needs and the amount of capital outlay they must secure in order to have the kind of production schedule they want.

C. There are many combinations to use. Plan ahead by considering all factors before selecting a design.

D. At least 2600 sq. ft. of production area is needed for a profitable operation.

III. Enrichment Activities

A. Visit a greenhouse range.

B. Ask a greenhouse grower to come in and speak to the group.

C. Conduct a cost analysis problem to determine potential profit of operation.

D. Invite Extension specialists in horticulture from the University of Kentucky to speak to the group.

E. Visit some school greenhouses.

F. Visit Eastern Kentucky University Horticulture Department.

IV. Suggested Teaching Materials

A. References for Lesson 2
   1. Flower and Plant Production in the Greenhouse, pp. 19-30.
   2. Ball Red Book, pp. 99-105.
   3. Grower Talks, January, 1972, pp. 21-22.
   4. Grower Talks, March, 1972, p. 10.
   5. Greenhouse Location and Orientation, Ky. Miscellaneous Bulletin 397.
   6. Preservative Treatment of Greenhouse Wood, Ky. Miscellaneous Bulletin 396.

7. Greenhouse Construction Cost and Production Practices, Ky. Miscellaneous Bulletin 352.
8. "Greenhouse Coverings" (Soon to be published by the University of Kentucky Extension Service).
9. "Greenhouse Structures" (Soon to be published by the University of Kentucky Extension Service).

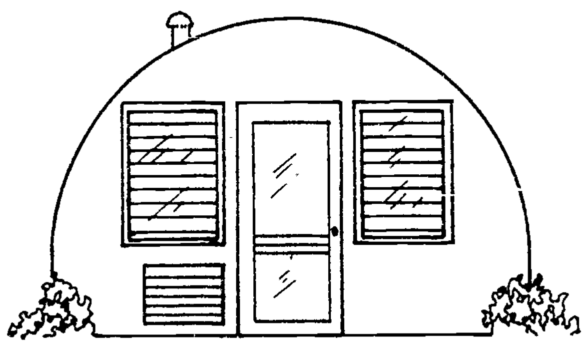
B. Resource Personnel
   1. Cooperative Extension Specialists -- U. K.
   2. Eastern Kentucky University Horticulture Department
   3. For specific personnel consult VoAg Directory of Resource People in Kentucky.

C. Audio-visuals
   1. Masters
      -1 Greenhouse designs
      -2 Typical range layout
      -3 Relationship of obstruction height to distance
      -4 Shadow effect on east west ridge and furrow greenhouses
      -5 Table 1 -- Typical Life of Untreated Heartwood in Ground Contact
      -6 Table 2 -- Toxicity of Preservatives to Plants Grown in Flats
      -7 Table 3 -- Effect of Treatment Method on Life of Southern Pine Stakes (2 X 4 X 18 inch nominal) using 5% Penta Preservative in Fuel Oil, Mississippi Tests
      -8 Table 4 -- Some Characteristics of Recommended Preservative Treatment for Softwoods
      -9 Table 5 -- Estimates of Material Costs for Three Widths of Plastic-film -- Covered Greenhouses Using a Rigid Frame Construction
      -10 Table 6 -- Cost (dollars per square foot) of Constructing a Plastic Greenhouse of the Kentucky Rigid Frame Type with an Automatic Environment Control System
      -11 Table 7 -- Comparison of Greenhouse Covering Costs
      -12 Table 8 -- Comparisons of Light Emissions of Various Greenhouse Coverings

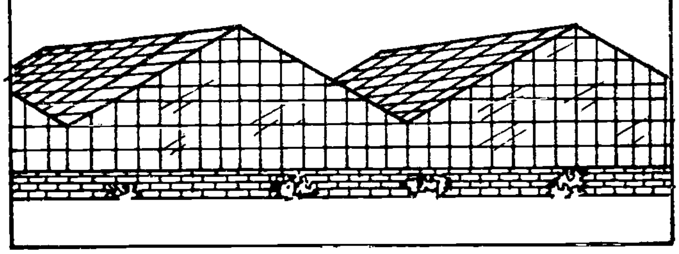
Greenhouse DESIGNS

GABLE

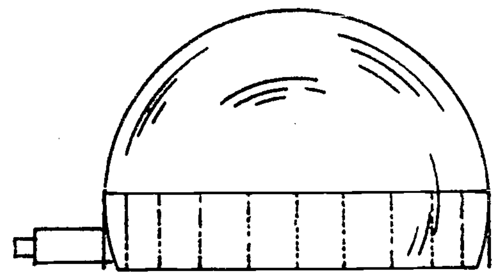
QUONSET



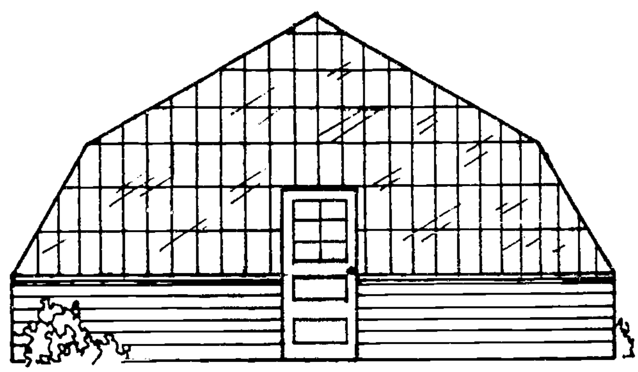
RIDGE AND FURROW



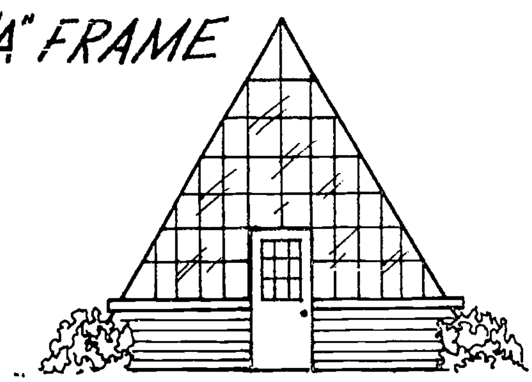
BUBBLE



GOTHIC

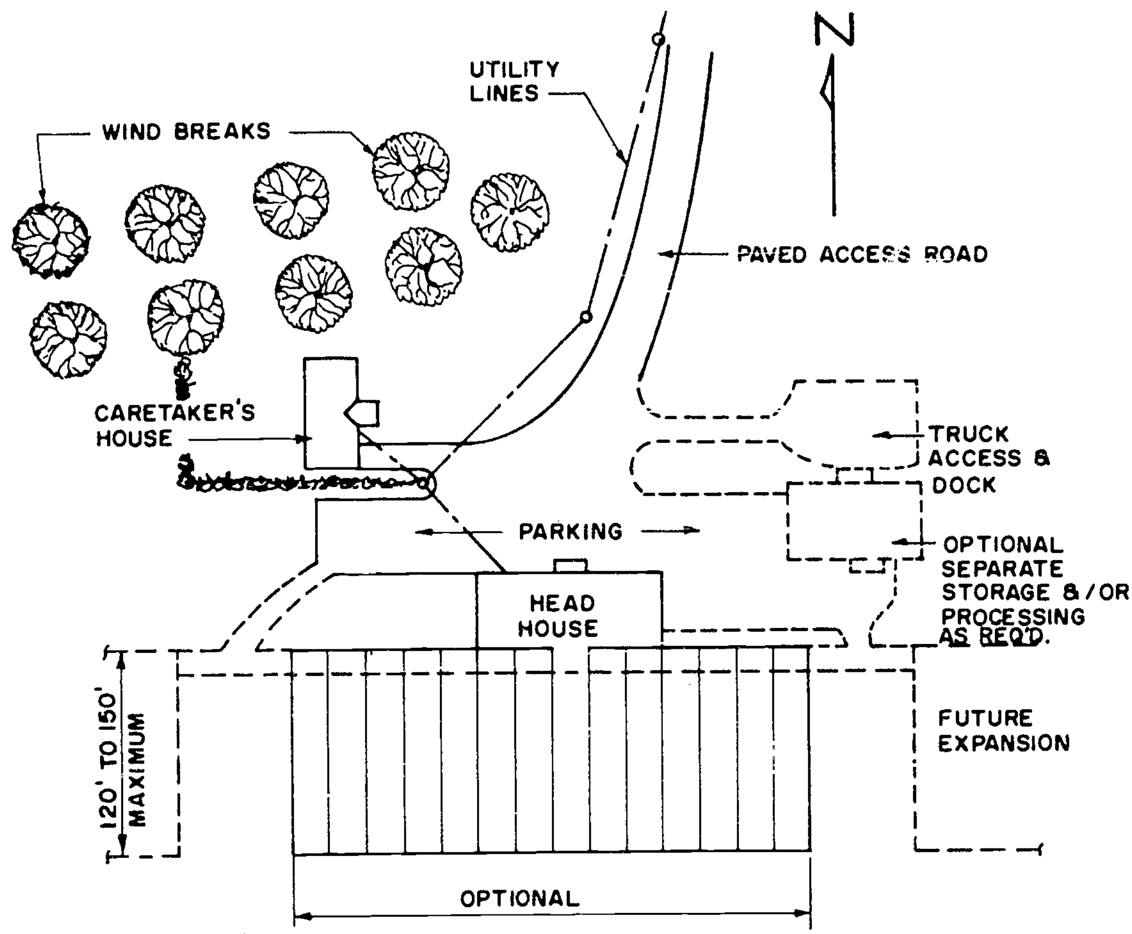


"A" FRAME



Adult 101-2-1

TYPICAL GREENHOUSE RANGE LAYOUT ON A LEVEL BUT
WELL DRAINED, SOUTHERLY EXPOSED SITE

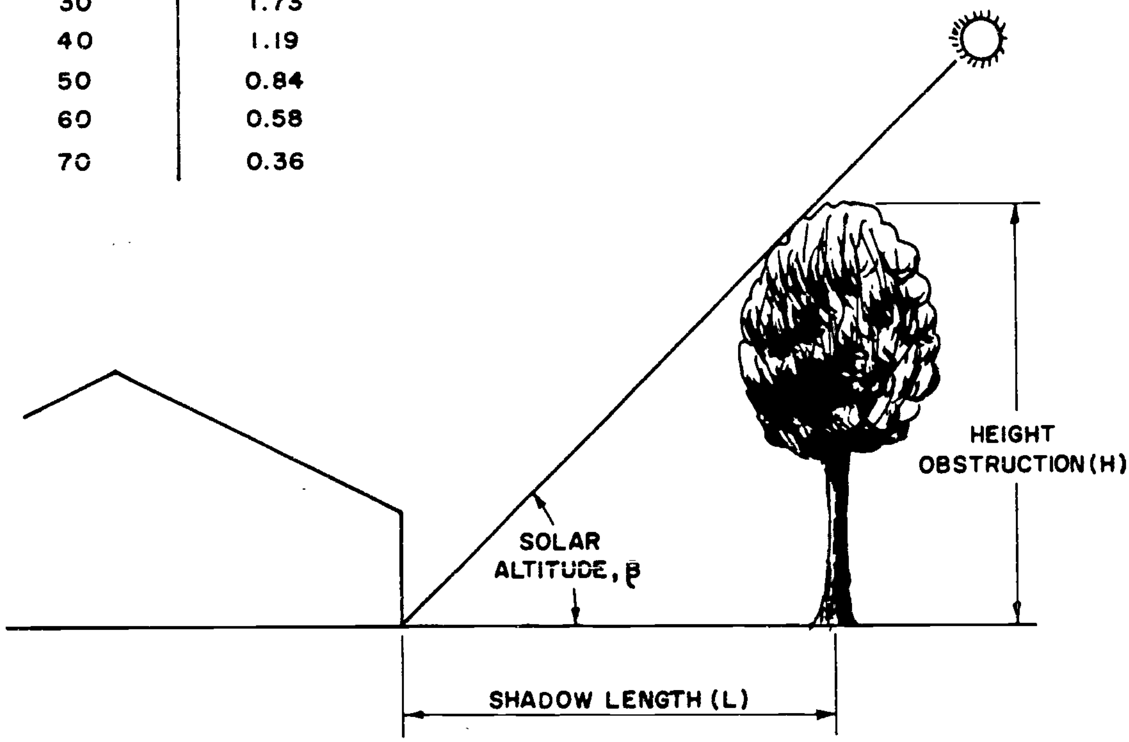


SOURCE: Ky. Misc. 397, p. 7.

Adult 101-2-2

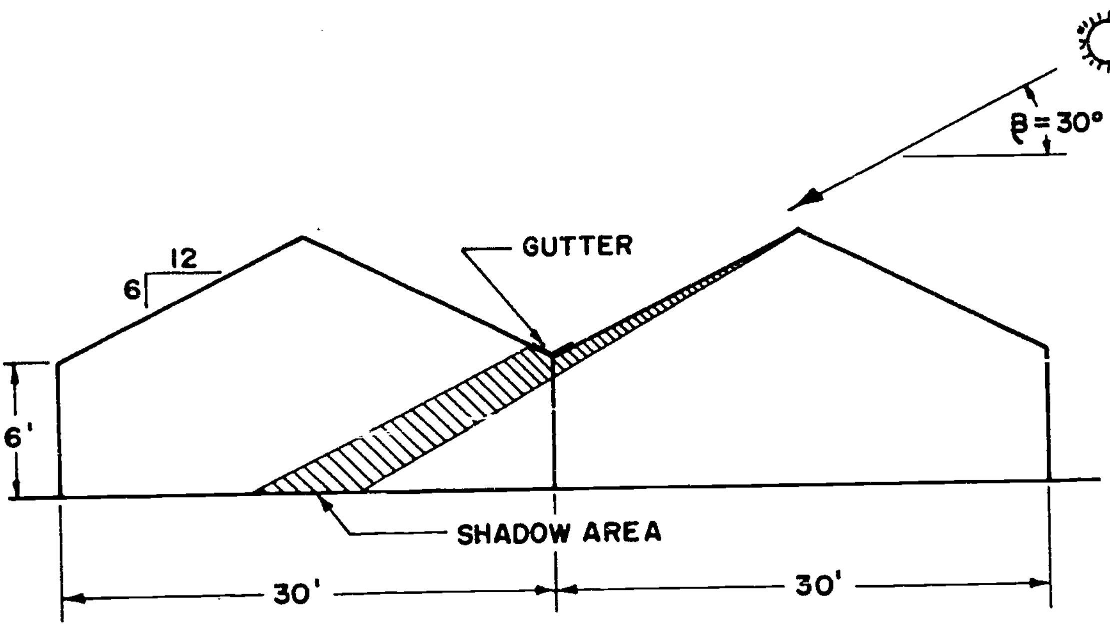
RELATIONSHIP OF OBSTRUCTION HEIGHT AND DISTANCE

ANGLE β	RATIO L/H
10	5.67
20	2.75
30	1.73
40	1.19
50	0.84
60	0.58
70	0.36



SOURCE: Ky. Misc. 397, p. 4.

SHADOW EFFECT ON EAST-WEST RIDGE AND FURROW GREENHOUSES



SOURCE: Ky. Misc. 397, p. 6.

Adult 101-2-4

*TABLE I.--Typical Life of Untreated Heartwood in Ground Contact

VERY RESISTANT (Over 15 Years Average Life)	
Black Locust	
Osage-Orange	
RESISTANT (7-15 Years Average Life)	
Cypress	
Red Cedar	
Redwood	
White Oak	
SLIGHYLY RESISTANT (2-7 Years Average Life)	
Ash	Larch
Beech	Maple
Birch	Pine
Cottonwood	Red Oak
Douglas Fir	Spruce
Hemlock	Yellow Poplar
Hickory	

*SOURCE: Kentucky Miscellaneous Bulletin 396.

*TABLE 2.-- Toxicity of Preservatives to Plants Grown in Flats

PRESERVATIVE	RETENTION Lb/cu.ft.	1st Year	2nd Year	4th Year	CONDITION OF FLATS 4th Year
Penta, 5% in Fuel Oil	.50	Severe	Moderate	None	No Decay
Creosote	8.00	Severe	Severe	Light	No Decay
Cooper Naphthenate, 10% in Fuel Oil	1.10	Light	Trace	None	Slight Decay
Erdalith[1]	.50	Trace	None	None	No Decay
Tanalith[1]	.50	Light	Trace	None	No Decay
Celcure[1]	.75	Light	Trace	None	No Decay
Chromated Zinc Chloride (CZC)[1]	.75	Moderate	Light	None	Slight Decay
Untreated Pine	----	None	None	None	Not Useable After One Year
Cypress Heartwood	----	None	None	None	Slight Decay

[1] Water-borne Salt-type Preservatives

*SOURCE: Kentucky Miscellaneous Bulletin 396

*TABLE 3.--Effect of Treatment Method on Life of Southern Pine Stakes (2 X 4 X 18 inch
Penta Preservative in Fuel Oil, Mississippi Tests

Treatment Method	Average Retention Lb/cu.ft	Condition of Stakes After 27 Years
Pressure	4.7	Destroyed by decay, fungi, termites
	9.6	20% Serviceable, 80% removed
18-Hour Soaking	2.4	Destroyed by decay, fungi, termites
3-Minute Dip	.8	Destroyed by decay, fungi, termites
Untreated	---	Destroyed by decay, fungi, termites

*SOURCE: Kentucky Miscellaneous Bulletin 396.

Treatment Method on Life of Southern Pine Stakes (2 X 4 X 18 inch nominal) using 5%
servative in Fuel Oil, Mississippi Tests

Average Retention Lb/cu.ft	Condition of Stakes After 27 Years	Average Life, Years
4.7	Destroyed by decay, fungi, termites	21.
9.6	20% Serviceable, 80% removed	(27+)
2.4	Destroyed by decay, fungi, termites	12.9
.8	Destroyed by decay, fungi, termites	3.2
---	Destroyed by decay, fungi, termites	2.3

iscellaneous Bulletin 396.

*TABLE 4.-- Some Characteristics of Recommended Preservative Treatment for Softwoods

<u>Erdalith or Greensalts</u>

- Toxic to decay and insects
- Paintable, clean, and odorless
- Very resistant to leaching
- Air or kiln drying is necessary before use
- Not readily available in most areas

<u>Osmose K-33 or Boliden K-33</u>

- Toxic to decay and insects
- Paintable, clean, and odorless
- Very resistant to leaching
- Readily available
- Air dry or kiln dry before use
- Will not bleed through concrete, plaster, or paint

<u>Osmosalts, Tantailith, or Wolman Salts</u>

- Toxic to decay and insects
- Paintable, clean, and odorless
- Somewhat fire retardant
- Non-corrosive to metals
- Subject to moderate leaching under extreme moisture conditions
- Air dry or kiln dry before use
- Not generally recommended for below-ground use

<u>Chemonite</u>

- Toxic to decay and insects
- Paintable, clean, and odorless
- Very resistant to leaching
- Will not bleed through concrete, plaster, or paint
- Air or kiln drying is necessary before use
- Not readily available in most areas
- High Cost

*SOURCE: Kentucky Miscellaneous Bulletin 396.

TABLE 5-- Estimates of Material Costs for Three Widths of Plastic-film — Covered Greenhouses Using a Rigid Frame Construction

Item	Item Cost Per Square Foot of Greenhouse		
	21' X 99'[1]	28' X 100'[2]	38' X 100'[2]
Frame lumber			
A. Treated	$0.1340	$0.1228	$0.1570
B. Non-treated	.0894	.0819	.1048
Plywood	.0194	.0143	.0202
Glue, resin	.0255	.0189	.0139
Paint	.0283	.0252	.0309
Concrete	.0123	.0252	.0185
Hardware	.0241	.0220	.0178
Covering	.0416	.0385	.0369
Total cost			
A. Wood-treated	.2852	.2669	.2952
B. Wood-non-treated	.2406	.2260	.2430

[1]"Cornell 21" design modified to a 6' side wall to allow for direct comparison with Kentucky rigid-frame greenhouses.

[2]Based on Kentucky Plan No. 771-1.

TABLE 6--Cost (dollars per square foot) of Constructing a Plastic Greenhouse Rigid Frame Type with an Automatic Environment Control System

Item	Dollars/sq
Materials for framework	$0.222
Labor to erect framework and attach film	0.082
Plastic film (UV "Poly")	0.029
Structure sub-total	
Heating and ventilation system	0.492
Electrical wiring	0.038
Environment control sub-total	
Irrigation system	0.078
Contingency factor (20%)	0.188
Total cost/sq. ft.	

ollars per square foot) of Constructing a Plastic Greenhouse of the Kentucky rame Type with an Automatic Environment Control System

n	Dollars/sq. ft.	
erials for framework	$0.222	
r to erect framework and attach film	0.082	
tic film (UV "Poly")	0.029	
Structure sub-total		$ 0.333
ing and ventilation system	0.492	
rical wiring	0.038	
Environment control sub-total		0.530
gation system	0.078	0.078
ingency factor (20%)	0.188	0.188
Total cost/sq. ft.		$1.129

*TABLE 7--COMPARISON OF GREENHOUSE COVERING COSTS

Material	Initial Cost cents per Sq. Ft.[1]	Installation Labor Cost[1]	Years Expected Life	Maintenance Cost Avg. per Year
Poly (4,6 mil)	1 to 1 1/2¢	1 1/2 to 2¢	1	-----
Poly UV (4, 6 mil)	2 to 2 1/2¢	1 1/2 to 2¢	2	----
Vinyl (8, 12 mil)	6 to 9¢	1 1/2 to 2¢	4	1/2¢[2]
Fiberglass 15% acrylic				
(4 oz.)	20 to 25¢	1 1/2 to 2¢	8-10	1 1/2¢[3]
(5, 6 oz.)	30 to 35¢	1 1/2 to 2¢	12-15	1 1/2¢[3]
Tedlar Coated, (5,6 oz.)	40 to 55¢	1 1/2 to 2¢	15-20	1/2¢[2]
Glass	50¢	2 to 3¢	30+	1-1 1/2¢[4]

[1]Estimated; actual costs depend on quantity and price of materials, quality of product of house, and skill of the installation crew.

[2]Washing every year or two to remove dust, pollution, etc. (Estimated one man to wash the entire surface of 30' X 60' house in 8 hours @ $2.00 per hour.)

[3]Washing every year or two as above, then smoothing with steel wool and applying resea 4 to 5 years. Labor estimated as above for washing (1/2¢) doubled for re-sealing pro resin sealer cost added (3¢) and pro-rated over 4 to 5 year interval (1¢ + 3¢ = 4¢ ÷ to 1¢ per year).

[4]Glass maintenance depends mainly on cleaning, replacement of broken panes, and re-gla Maintenance costs estimated at 1/2 man-day (4 hrs.) per month for 10,000 sq. ft. hous $50 per year for materials.

---

*SOURCE: "Greenhouse Coverings," by George Duncan and John Walker, soon to be publish ative Extension Service.

*TABLE 7--COMPARISON OF GREENHOUSE COVERING COSTS

	Initial Cost cents per Sq. Ft.[1]	Installation Labor Cost[1]	Years Expected Life	Maintenance Cost Avg. per Year	Cost per Year per Sq. Ft.
	1 to 1 1/2¢	1 1/2 to 2¢	1	-----	2 1/2 - 3 1/2¢
	2 to 2 1/2¢	1 1/2 to 2¢	2	----	2 to 2 1/2¢
	6 to 9¢	1 1/2 to 2¢	4	1/2¢[2]	2 to 3¢
c	20 to 25¢	1 1/2 to 2¢	8-10	1 1/2¢[3]	3 to 3 1/2¢
	30 to 35¢	1 1/2 to 2¢	12-15	1 1/2¢[3]	2 1/4 - 2 1/2¢
5,6 oz.)	40 to 55¢	1 1/2 to 2¢	15-20	1/2¢[2]	2 1/2 to 3¢
	50¢	2 to 3¢	30+	1-1 1/2¢[4]	2 to 3¢

sts depend on quantity and price of materials, quality of product, local wages, type of the installation crew.

r two to remove dust, pollution, etc. (Estimated one man to wash and clean or scrub f 30' X 60' house in 8 hours @ $2.00 per hour.)

r two as above, then smoothing with steel wool and applying resealing resin every estimated as above for washing (1/2¢) doubled for re-sealing process (1¢) with ded (3¢) and pro-rated over 4 to 5 year interval (1¢ + 3¢ = 4¢ ÷ 4 to 5 years - 4/5

pends mainly on cleaning, replacement of broken panes, and re-glazing of loose panes. timated at 1/2 man-day (4 hrs.) per month for 10,000 sq. ft. house, $2.00 per hour, erials.

Coverings," by George Duncan and John Walker, soon to be published by U.K. Cooper- sion Service.

*TABLE 8--COMPARISONS OF LIGHT EMISSIONS OF VARIOUS GREENHOUSE COVERING

TYPE OF COVERING	Sunny Day (10,000 foot-candles outside). Per cent of available light transmitted through the roof.	Cloudy Day (1,750 foot-candles outside). Per cent of available light transmitted through the roof.
New Glass--5 years	80%	60%
Old Glass--30 or 40 years, close bars.	65%	50%
New rigid plastic--1 year.	70%	70%
Old rigid plastic--7 years, acrylic-modified.	50%	46%
Polyethylene, new, double-layer	60%	60%

NOTE: The 7-year-old plastic had not been steel-brushed, treated with plastic refinish glass and the new rigid plastic came off at about a draw, but the 7-year-old rig below 30-year-old glass. And both were lower in light transmission than new doub ethylene.

The worst score of all (in per cent of light transmitted) was the 7-year-old rig

New rigid plastic transmitted more light on a cloudy day than even new glass. Bu aged, glass performed better.

These readings were taken with a simple $23 light meter.

*SOURCE: George J. Ball, Inc., Grower Talks, March, 1972.

E 8--COMPARISONS OF LIGHT EMISSIONS OF VARIOUS GREENHOUSE COVERINGS

	Sunny Day (10,000 foot-candles outside). Per cent of available light transmitted through the roof.	Cloudy Day (1,750 foot-candles outside). Per cent of available light transmitted through the roof.	Average of the two
	80%	60%	70%
0 years,	65%	50%	57%
-1 year.	70%	70%	70%
-7 years,	50%	46%	48%
double-layer	60%	60%	60%

plastic had not been steel-brushed, treated with plastic refinisher. Actually, new
new rigid plastic came off at about a draw, but the 7-year-old rigid plastic was well
old glass. And both were lower in light transmission than new double-layer poly-

e of all (in per cent of light transmitted) was the 7-year-old rigid plastic.

tic transmitted more light on a cloudy day than even new glass. But after both
rformed better.

were taken with a simple $23 light meter.

ll, Inc., Grower Talks, March, 1972.

LESSON 3

CONTROLLING ENVIRONMENT INSIDE A GREENHOUSE

Objective -- To develop the effective ability of operators to control environmental growing conditions inside a greenhouse.

Problem and Analysis -- What environmental control devices are needed to control plant growing conditions inside a greenhouse?

-Conditions to be controlled
-Control devices
-Operation of control devices
-Selection of equipment

Content

I. Conditions to be controlled.

A. Temperature.

1. Plants are tempermental when it comes to temperature. For optimum plant growth, temperature should be maintained within a degree or two of optimum settings. Failure to maintain correct temperature will cause poor growth and delayed crops.
2. Temperature should be checked by a reliable thermometer where the plants are growing rather than at convenient eye level.
3. Vertical level at which the thermometer is placed is critical. Temperature variance from floor to ceiling may be as much as 30°.
4. Temperature is closely related to air circulation. Several thermometers should be placed around within the house and temperatures found under varying conditions should be noted.
5. Don't take it for granted that everyone knows what temperature should be used; post correct temperature needed for night, sunny days, and cloudy days.
6. Remind workers (and students) that temperature should be within 1° either way. Some may be inclined to think that any temperature above the posted temperature is good enough.
7. In managing temperatures in the greenhouse, heat is either being added or removed.
   a. Heating.
      (1) Plants are usually tall and thin at

high temperatures.

(2) Temperature recommendations are sometimes based on night temperatures with day temperatures 5-10 degrees higher.

(3) Heat (high temperature) is difficult to control during hot, humid summer weather.

(4) Radiant energy from the sun will be absorbed by plants and soil and is changed to heat energy. But when sun rays are blocked out, the plants continue to radiate heat to the air and consequently may be cooler than the air surrounding them. This sometimes causes an invisible film of moisture to form on the foliage of plants providing an excellent place for the germination of disease spores.

(5) Heating requires more attention on a partly cloudy day because temperatures may vary greatly.

b. Cooling.

(1) In hot, humid summer weather it is very difficult to cool down the greenhouse. It may not be practical, economically, to install cooling equipment.

(2) Many greenhouse plants stop growing when temperatures go up above 90° F.

(3) Cool temperatures cause plants to be shorter and heavier. Excessively cool temperatures can delay a crop.

(4) To successfully carry plants through summer months in the greenhouse it will be necessary to provide sufficient cooling equipment to do the job.

B. Ventilation.

1. Introduction of outside air inside the greenhouse is necessary in order to regulate greenhouse temperature, adjust the humidity, provide air movement around plants and provide carbon dioxide and oxygen to the plant.
2. This may be accomplished by use of ridge ventilators, exhaust fans and shutters, or through a fan jet system with convection tubing.
3. Air circulation within a greenhouse without introducing outside air is necessary to prevent "cold spots" in the greenhouse and to remove the film of moisture that may collect on plants.
4. As temperature goes down, relative humidity may increase.

C. Relative humidity.

1. Relative humidity is the amount of water vapor in

the air, expressed as a percentage of what the air could hold at a given temperature. A relative humidity of 50 per cent means that the air is holding 50 per cent of the moisture it could hold at that temperature.

2. High relative humidity is conducive to disease development.
3. Some plants do better in low humidity while others, such as tropical foliage plants, thrive on high humidity (80 per cent or better).
4. There are systems available to control relative humidity.

D. Carbon Dioxide.

1. Raising the level of CO_2 in the greenhouse during periods of low light results in improved growth. Normal outside air contains 300 PPM of carbon dioxide; raising this to 1200 PPM of CO_2 in the greenhouse may be economically worthwhile to some plants.

E. Light.

1. An important factor in the growth of plants, light varies in intensity, quality and duration. Bright sunshine may average about 10,000 foot candles, while winter light may be down to 500 foot candles. Plants vary in their responses to light but photosynthesis is most efficient at about 6,000 foot candles.
2. Certain plants are influenced by length of day as to time of flowering. Mums and poinsettias flower when the dark period is 12 hours or longer.

II. Control devices.

A. Heating.

1. It is difficult to precisely determine heat and ventilation requirements.
2. Growers must consider shape, size and covering of the greenhouse.
3. The relationship of outside temperature to inside temperature is very important.
4. Some heating systems are:
   a. Steam (usually used in larger greenhouse ranges).
   b. Hot water
   c. Coal boilers
   d. Fuel oil
   e. Unit gas heaters (propane or natural gas is used in smaller houses).
5. Consult the Extension Agricultural engineer at the University of Kentucky for specific greenhouse

heating problems.

6. A new Kentucky Extension bulletin has recently been submitted for publication: "Estimating Greenhouse Heating and Ventilation Requirements" by John A. Walker and George A. Duncan.

B. Cooling.
   1. For many crops carried through the summer months cooling will be essential.
   2. Shading compound applied on the roof will reduce heat.
   3. Fog mist must be fine enough to evaporate without any fallout on plants; use water pressure of about 500 Psi.
   4. Another method is the washed air, fan and pad cooling system, which draws air by the use of fans through wet pads.

C. Ventilation.
   1. Air circulation is important both in summer and winter.
   2. Systems include:
      a. Exhaust fans and shutters
      b. Fan jet system in ridge of greenhouse
      c. Ridge ventilators
   3. Consult Extension agricultural engineers at the University of Kentucky and the Bulletin referred to under A6 above.

D. Relative humidity.
   1. If dry, inject mist into the air.
   2. If too high, use circulation of air and an increase in temperature together with ventilation.
   3. It may sometimes be difficult to control relative humidity during cold weather.

E. Carbon Dioxide.
   1. CO_2 may be supplied from compressed gas stored in tanks throughout the greenhouses.
   2. CO_2 generators may be used; example, Red Head (brand) CO_2 generator.

F. Light.
   1. When maximum light is needed, be sure the greenhouse covering is clean.
   2. Shade for lower light intensity with shading compound, muslin, or plastic screen above plants.
   3. Control the photoperiod of plants.
      a. To extend the light period, place light bulbs controlled by a day/night timer above the plants; this equipment is usually operated for a four-hour period in the middle of the night.

b. To reduce day length, completely cover plants with black cloth for a 12 hour period.

4. Check such things as night lights around the greenhouse. These may produce enough light to keep flowers from setting (especially poinsettias).

III. Operation of control devices.

A. Grower must prevent extreme fluctuations in the greenhouse environment.

B. Thermometers should be placed at strategic locations throughout the greenhouse at plant growing level.

C. Experiment with automatic control devices, consulting thermometers to arrive at the correct temperature.

D. Post settings of thermostats and control devices where other operators can see them.

E. Automatic controls should be checked regularly for accuracy.

F. Conditions that can be controlled automatically are temperatures, ventilation, relative humidity, carbon dioxide and light.

IV. Selection of equipment.

A. Determine size, shape and type of covering the greenhouse will have.

B. Determine the kind of plants to be produced.

C. Consult extension agricultural engineers at the University of Kentucky with this information or secure a copy of the bulletin, (Estimating Greenhouse Heating and Ventilation Requirements).

D. After requirements are determined it will be necessary to contact greenhouse equipment suppliers, giving them full information on your requirements; examples are: Jednah Floral Co., Geigers, The National Greenhouse Suppliers, and others.

E. You may decide to secure materials locally, depending upon availability and your ability.

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Things to be brought out by the teacher:
   1. To successfully produce plants in a greenhouse an operator must maintain optimum growing conditions for the plants.
   2. Knowledge of these conditions is necessary.
   3. The greenhouse is an enclosed space of air; proper handling of this space controls the growth of plants in this space.
   4. There are many control aids available to the operator.
   5. Knowing how far they can go in controlling atmospheric conditions is extremely important to operators for making sound decisions in securing equipment.

B. Things to be brought out by students:
   1. Observations of plant response to conditions such as humidity, temperature, light.
   2. Conditions such as
      a. Heat build-up in a structure on extremely sunny days compared to cloudy days.
      b. Dryness of a building when heat is being applied over long periods.
   3. Their knowledge of thermostats, time clocks, time delay switches, unit heaters, shutters, fans, and other control mechanisms.

II. Conclusions

A. Help should be secured from the Agricultural Extension Service, University of Kentucky, in selecting a heating and ventilating system.

B. Temperature can and should be controlled to within 1-2° F. for best results.

C. Ventilation and continuous air circulation are important in the greenhouse.

D. Most operators should rely on automatic controls to control conditions inside the greenhouse.

E. Knowledge can be secured (and the results are well worth the effort) for controlling conditions in the greenhouse.

III. Enrichment Activities

A. Visit greenhouses at the University of Kentucky.

B. Attend field days at the University of Kentucky.

C. Visit greenhouses at Eastern Kentucky.

D. Visit large commercial greenhouses in the area.

E. Calculate heating and ventilation requirements for a 3,000 square foot greenhouse.

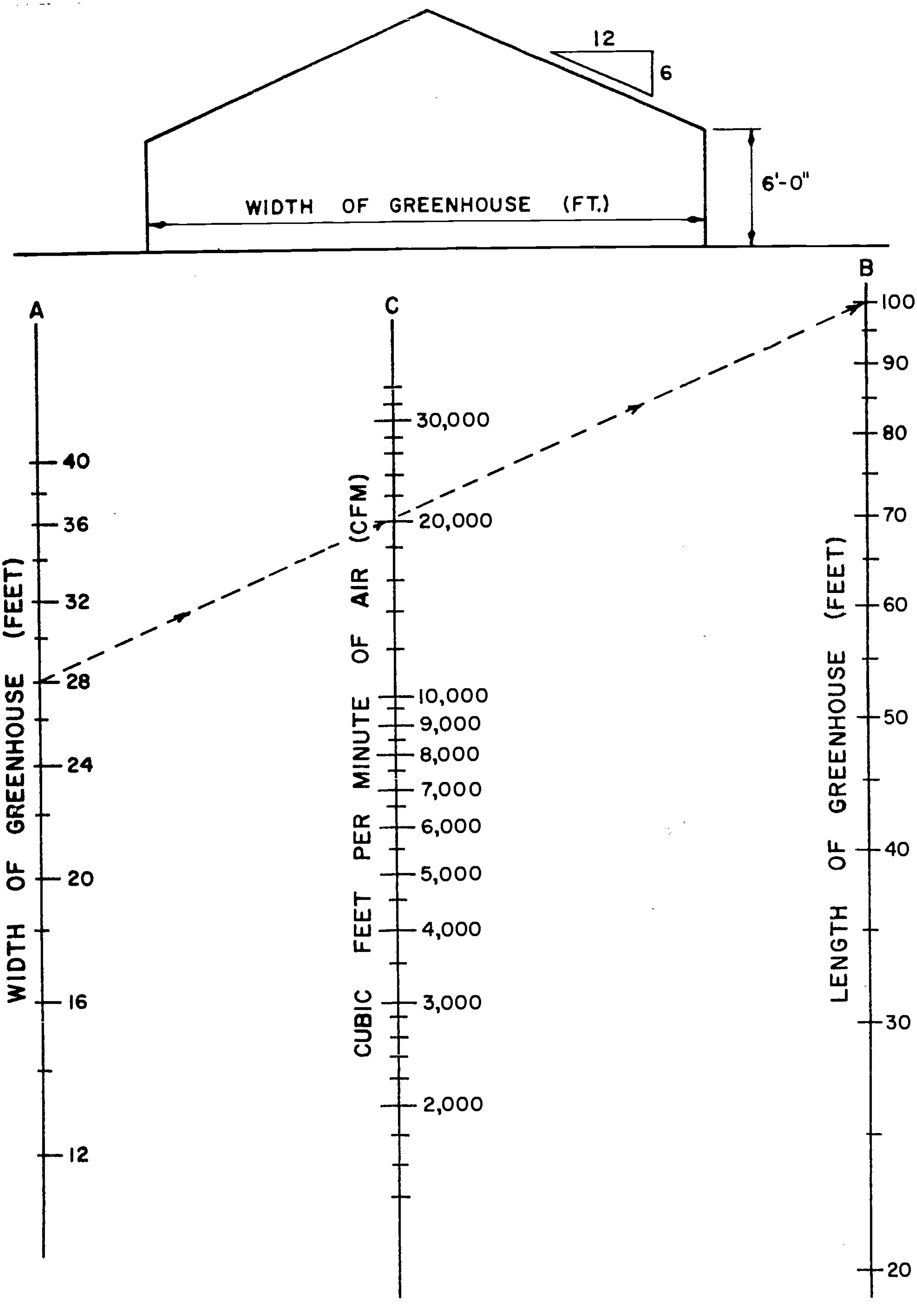
IV. Suggested Teaching Materials

A. References for Lesson 3
1. Flower and Plant Production in Greenhouses, pp. 30-33, 64-75.
2. Kentucky Miscellaneous Bulletin, "Estimating Greenhouse Heating and Ventilation Requirements".
3. Proceedings, Kentucky Greenhouse Flower and Vegetable Grower Conference, 1972.
4. The Green House Worker, pp. 105-112.
5. Greenhouse Crop Production, pp. 23-34.

B. Resource Personnel
1. Cooperative Extension Specialists -- U.K.
2. Eastern Kentucky University Horticulture Department.
3. Consult local sources.
4. For specific personnel see Vo-Ag Directory of Resource People in Kentucky.

C. Audio-visuals
1. Masters
   -1 Ventilation for Greenhouses
   -2 Time Clock

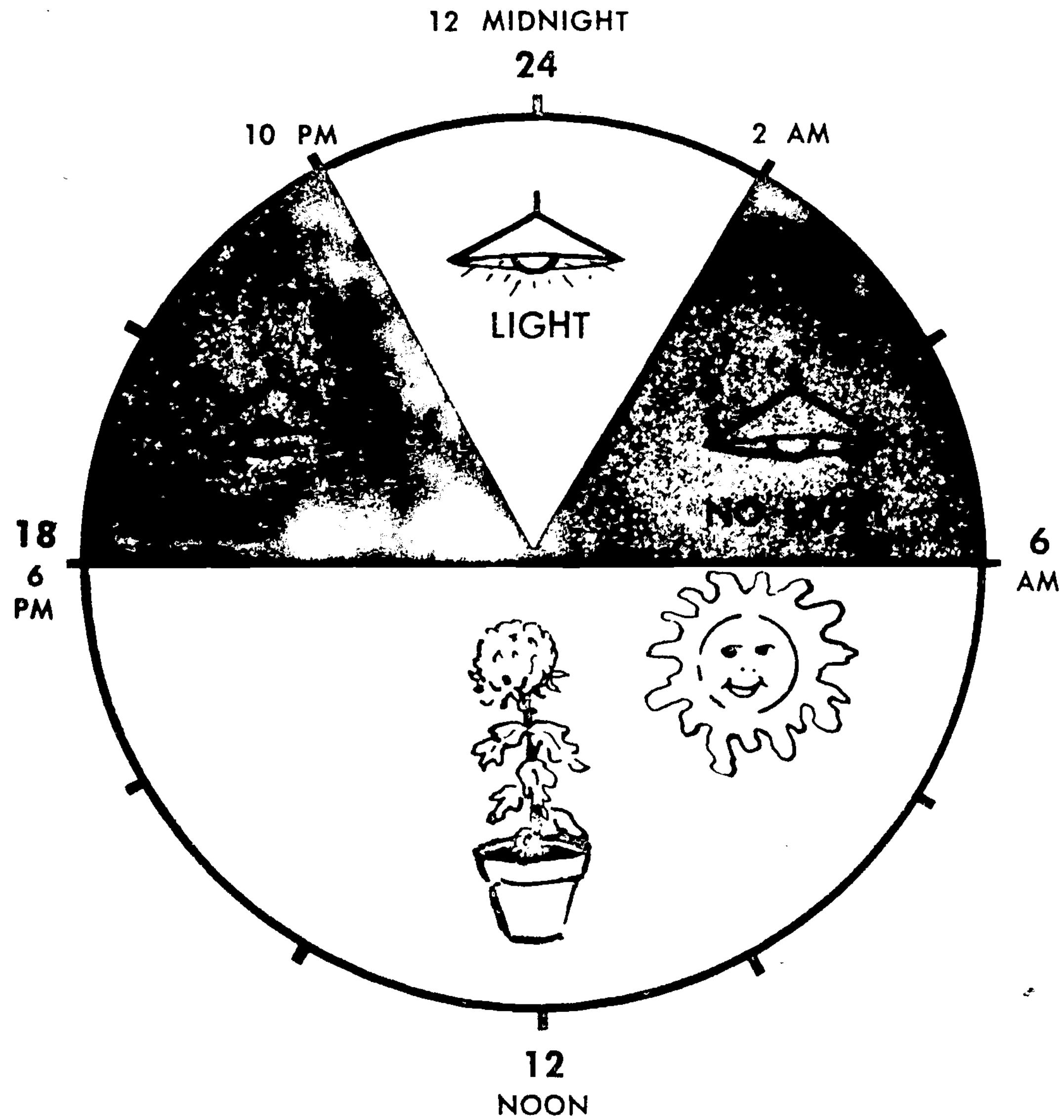
VENTILATION FOR GREENHOUSES



SOURCE: Kentucky Agricultural Engineer, Jan., Feb., March, 1965, p. 10.

LIGHTING TIME

EXPRESSED ON A TWENTY FOUR HOUR CLOCK



SOURCE: <u>Greenhouse Crop Production</u>, p. 34.

LESSON 4

PREPARING GROWING MEDIA

Objective -- To develop the effective ability of operators to prepare good greenhouse plant growing media.

Problem and Analysis -- How should we prepare greenhouse soil media for growing plants?

-Characteristics of good greenhouse soil media
-Preparing groundbeds
-Preparing container soil media
-Sterilization procedures

Content

I. Characteristics of good greenhouse soil media.

A. Soil media are composed of materials in solid, liquid, and gaseous forms; for satisfactory plant growth they must exist in the proper proportions. In addition, good media should:
   1. Have sufficient moisture retention characteristics.
   2. Allow drainage for excess water.
   3. Be free from weeds, diseases and insects.
   4. Not have an excessive salt level.
   5. Tolerate sterilization.

B. Soil is a very important factor in producing quality plants in the greenhouse.
   1. Field soil will vary from one region to another. The best natural field soil would be a loam; however, some organic matter would probably be needed.
   2. Avoid soils that have had weed killers used on them because of possible harmful residual effects.
   3. Clay soil will need a porous material added to improve drainage, while sandy soil may need organic matter to improve the buffering effect.
   4. Soil additives include organic and inorganic materials.
      a. Organic additives are:
         (1) Peat (the most common source of organic matter in greenhouse soils).
         (2) Plant residues such as ground corn cobs, straw, sugar cane, various hulls.
         (3) Sawdust and shavings (well rotted).
      b. Inert additives which improve drainage and aid aeration are: sand, Perlite, Vermiculite, calcined clay, fine cinders, and pumice.

5. Trend in many areas is to use less natural field soil and to grow plants in "soil-less" mixtures.
   a. Available are such commercially prepared mixes as Jiffy-Mix, Pro-Mix, and Redi-Earth (trade names).
   b. Mixes you may be able to prepare are:
      (1) Cornell Peat-Lite Mix:
         -Mix A

Canadian sphagnum peat moss	11 bu.
Horticultural grade vermiculite (No. 2 or 4)	11 bu.
Ground limestone (preferably dolomitic)	5 lbs.
Super phosphate 20% powdered	1 lb.
5 - 10 - 5 fertilizer	2 to 12 lbs.

         -Mix B
         Same as A except horticultural perlite substituted for vermiculite

      (2) U. of Ky. Mix -- (Dick Henley)

Vermiculite #2	11 bu.
Shredded sphagnum peat moss	11 bu.
10 - 10 - 10 fertilizer	3 lbs.
Superphosphate 20% powdered	2 lbs.
Dolomitic limestone	5 lbs.
Chelated iron (Sequestrene 330)	2 Tbsp.
Borox (11% Boron)	1 Tbsp.
Surfactant (non-ionic)[1]	2 ounces

   c. Suggested soil mixes are:
      1 part heavy soil
      1 part inorgnic particles
      1-2 parts organic particles

      Or:
      1 part light soil
      1 part organic particles
   d. Kind of field soil, labor, machinery to handle soil, and expense will determine whether to use soil mixes or soil-less mixes.
6. Nearly all field soil will have to be amended with either organic or inorganic particles to make it desirable for groundbeds and container-grown plants.

II. Preparing groundbeds for planting.

A. Spade groundbeds, but do not pulverize the soil too fine.

B. Incorporate phosphorus and potash, and lime (if needed), at the time of soil preparation.

C. Soil should be slightly moist.

---

[1](Surfactant is applied in approximately 20 gallons of water)

D. For steaming beds, if using perforated tile or pipe for beds over 3 feet wide, dig two trenches down the center of beds to bury lines. Slightly mound soil over pipes and cover with vinyl plastic.

E. After sterilization, rake soil down smoothly, avoiding any low places in the groundbeds. (Soil should be within 1 inch of the top of the side.)

F. For more information on fertilization see Lesson six.

III. Preparing container soil.

A. Soil should be thoroughly mixed.

B. Sterilize in a box, wagon bed or other suitable container.

C. Soil should be covered and stored until used.

D. See Lesson six for fertilizing practices.

IV. Sterlizing soil mixes.

A. Steam sterilization.
1. Perforated tile or pipe should be buried in the soil.
2. Canvas line may be placed on top of the beds or on the soil.
3. Cover soil completely with vinyl cover.
4. Temperature should be brought up to 180^{o} and maintained for at least 30 minutes.
5. Soils should be moist when sterilized.
6. Soil toxicity problems may develop if temperature goes over 180^{o}.

B. Chemical sterlization.
1. Methyl bromide.
   a. Soil should be moist and loosened.
   b. Soil temperature should be between 55^{o} and 75^{o} F.
   c. Soil is covered with plastic and gas is released under the cover (use 2 pounds per 100 sq. ft.).
   d. Keep soil covered for 48 hours and then remove and allow to air out at least 3 days before planting.
   e. If the material used is a methyl-bromide/chloropicrin combination, soil should be aired at least 10-14 days.
   f. Methyl-bromide is toxic to humans; directions upon the container should be read carefully and followed to the letter.
2. Vapam soil drench.
   a. Vapam is a water soluble soil fumigant.
   b. It is applied by sprinkling on the prepared seed-bed 1 quart of the Vapam material in 2 to 3 gals. of water over 100 sq. ft. of area.
   c. Soil temperature should be 60^{o} to 75^{o} F.

d. Seal the soil with water or by rolling.
e. Avoid inhalation of fumes or spilling on the skin.
f. Read directions on the container.
g. You may cover for 5-7 days and then air for 21 days.

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Things for the teacher to bring out:
1. Composition of various kinds of soil.
2. Meaning of structure and texture of soil.
3. Amount of air and water space needed in soil.
4. Why drainage problems are more serious in a greenhouse than in the field.
5. The fact that soils can be manipulated by using organic or inorganic particles.

B. Things to be brought out by class members:
1. Observation of various kinds of soil.
2. How too much water affects plants.
3. Soil sterilization practices they have used.

II. Conclusions

A. In almost every case field soils must be amended to make a good growing mixture for the greenhouse.

B. Commercially prepared "soil-less" mixes may compete favorably with your own mixes as far as prices are concerned.

C. Soil-less mixes may be better for bedding plant production.

D. The grower will have to experiment with his own soil mixes to get a good one.

E. All soils, containers, and equipment should be properly sterilized.

III. Enrichment Activities

A. Secure samples of media components; prepare appropriate mixes.

B. Have local greenhouse managers discuss media with the class (panel discussion).

C. Prepare a groundbed, container and flat in the school greenhouse.

D. Conduct a test of soil sterilizers: use an infected soil, make "before and after" tests.

IV. Suggested Teaching Materials

A. References

1. Plant Propagation Principles and Practices, pp. 32-40.
2. Flower and Plant Production in the Greenhouse, pp. 79-86.
3. Proceedings: Kentucky Greenhouse and Vegetable Grower Conference, 1972. pp. 23-24.
4. Greenhouse Crop Production, pp. 56-58.
5. Grower Talks, September, 1972, pp. 8-11.

B. Resource Personnel

1. Consult local sources.
2. Cooperative Extension Horticulture Specialists.
3. Eastern Kentucky University Horticulture Department.
4. For specific personnel consult VoAg Directory of Resource People in Kentucky.

LESSON 5

PROPAGATING SELECTED GREENHOUSE PLANTS

Objective -- To develop the effective ability of a beginning greenhouse operator to propagate plants.

Problem and Analysis -- What propagation methods should we use for best results?

-Methods of propagation
-Media to use
-Containers and beds
-Securing materials for propagation

Content

I. Methods of propagation.

A. The most common means of plant reproduction in the greenhouse are by seeds and cuttings.
   1. Sexual reproduction generates new plants from a seed. Seed is formed when pollination occurs; a seed is a miniature living plant, breathing slowly and using stored food.
   2. Asexual reproduction occurs when new plants develop from a portion of the stock plant. This method uses the regeneration ability of a portion of the plant to reproduce an exact likeness in a new plant.
   3. Both methods are used in greenhouse production under varying conditions. Cuttings are usually limited in flower culture to stem and leaf cuttings, and to tip cuttings.

B. A great portion of bedding plant sales comes from plants propagated by seed. To successfully propagate by seeds, give careful attention to these things:
   1. Viable seed. It is important that you establish a source of good seed with high germination. Seed should be purchased from a reputable seed dealer.
   2. Good soil media. (Roman numeral II discusses this fully.)
   3. Good containers. (Roman numeral III discusses this item.)
   4. Sowed at the proper depth.
      a. Seed is a small living plant.

b. Smaller seed has a smaller food supply for the plant. Small seeds should not be covered deeply.
c. For petunias and similar seed, make shallow depressions (1/8 inch or less). Keep rows about 1 1/2 inches apart in a suitable flat. Shake seed from the packet, spacing them about 1/8 inch apart. Jiffy mix or peat may be screened over the seed, using just enough to thinly cover the top of the soil.
d. Flats should be thoroughly watered before seed is sown.
e. Watering after a flat is sown must be done with a misting nozzle or watered from the bottom to prevent knocking the seed into a bunch or splashing them out of the flat.
f. Larger seed may be sown deeper.

5. Correct moisture.
   a. After flats have been filled to the proper level, place them in a container and let water soak through them from the bottom. If possible, do this 12 hours before seeding. You can then let the flats drain and settle before seeding.
   b. If Jiffy mix or mixes containing peat are used, be sure the trays are thoroughly soaked before seeding.
   c. After trays are seeded and if they have been presoaked, moisten the top of the soil lightly, taking care not to dislodge the seed, and place the trays on propagation benches.
   d. Watering from this stage can be done in two ways.
      (1) Cover the trays with polyethylene film and do not water until germination has taken place. Care must be taken that the temperature in the cover flats does not rise excessively (above 80° F). You may need to shade lightly if in bright sun. Germination for most plants will take place in about 5 to 14 days.
      (2) Mist system. The trays can be placed under a misting system that will put out a fine water mist at regular timed intervals. This takes the place of covering and keeps the soil from drying out. The mist system may be turned off at night unless the heaters dry the soil extensively. Timed intervals should be established by conditions. Example: 5 seconds every 5 minutes or 5 seconds each minute.

6. Securing correct temperature.
   a. Most bedding plants require 70° F. (See table at end of lesson.)
   b. To prevent heating a large area to 70° F., develop propagation benches.
   c. Place steam lines under benches to bring the flats to 70° F. temperature. Place soil heating cables in sand.

d. Propagating mats are available.
e. Seeding directly to growing containers will cause you to heat a large area of the house. This is now being done in some areas.

C. Some plants are more rapidly propagated from cuttings than seed. It also makes for more efficient use of the greenhouse area to be able to carry stock plants to make cuttings. Most mums are propagated from cuttings. Generally, rooted cuttings are purchased. Geraniums, foliage plants, and some bedding plants may be propagated from cuttings; moisture and soil media are the two most important factors. It is important to have a reliable source of cuttings that are disease free. Stock plants or mother plants are usually kept for this purpose in an area other than the propagation area.

1. Description of cuttings. Most flower cuttings (herbaceous) are usually 4" long. They may be taken from the top of the branch (stem-tip cuttings) or lower if they contain leaf buds (lateral leaf-bud cuttings). Generally, cuttings will root more rapidly when taken from the juvenile growth phase. High levels of nitrogen in stock plants are not conducive to good rooting. A good supply of carbohydrates in stock plants is conducive to good rooting.
2. Treatment of cuttings. Cuttings will root without auxins, but they will root faster and have better root systems when treated. There are many materials to use but indolebutyric acid and napthalaneacetic acid give the best results in most cases. Trade names usually referred to are Rootone, Hormex, and others.
   a. Auxins come in both liquid and powder form.
   b. Different formulations are available.
   c. Indolebutyric acid is probably the best material for general use because it is nontoxic over a wide concentration range and is effective for a large number of plant species.
      (1) Complete directions come with materials together with a list of plants which respond.
      (2) When using this material do not dip cuttings in the container. Spread a small portion on wax paper or aluminum foil. A convenient sized handful of cuttings is then dipped and rotated in the powder. Shake off excess and insert cuttings immediately into the rooting medium. Be sure you treat the basal end. In using the liquid form the basal inch of the cutting is soaked in a dilute solution of the material for about 24 hours just before they are inserted into the rooting medium. Concentrations used vary from 20 ppm to about 200 ppm. A concentrated solution (500 to 10,000 ppm) of the chemical may be used and the basal ends of the cuttings are dipped for about 5 seconds and then are inserted in rooting medium.

(3) Fine sand is the best medium for most herbaceous cuttings. It should be fine enough to make good contact with the cutting. This will allow some moisture retention around cuttings, yet be coarse enough to allow water to drain freely through it. Clean, sharp, plaster sand, free from organic matter and soil and sterilized is excellent.

(4) Heat applied to the flat bottom at 70°- 75° F. will usually promote rooting.

(5) Maintain strict sanitation. In addition, you may use Dexone Terraclor. Use a sharp straight knife for cuttings. Some propagators may prefer breaking. Wash hands, knives, or tools in LF10 every 10 minutes while at work.

(6) Containers. Use properly heated beds of sand or flats of sand, but no fertilizer of any kind in the propagating mixture.

(7) Misting. The cutting will lose water because it still has leaf surface but no roots. Mist 10 seconds per 8 minutes on sunny day, one-half of that rate on cloudly days. Misting prevents having to provide shade to cuttings. If you provide shade, use as little as will be effective. Too much shade will cause cuttings to be soft and stretched.

II. Media to use.

A. Use of good media permits the cuttings to be in contact with the soil, holds some moisture, and permits excess to drain off rapidly. It is clean, sterile, and should provide good aeration. Examples of artificial soil media are:

1. Sand — a widely used rooting medium. It is readily available and relatively inexpensive. Plaster sand is recommended.
2. Peat moss increases water-holding capacity of soil and, consequently, the danger of over-watering. If kept too wet it will sometimes cause deterioration of the roots soon after they are formed.
3. Shredded sphagnum moss is sometimes used as rooting medium for stems, leaf and root cuttings.
4. Vermiculite is a micocesus mineral which expands markedly when heated. Vermiculite ore is run through furnaces at 2000° F. popping the layers apart forming small sponge-like particles. Graded to 4 sizes: Numbers 1 and 2 are horticulture grades; numbers 3 (1-2 mm.) and 4 (0.75-1 mm) are the seed germinating grades.
5. Perlite is a gray-white material of volcanic orgin; it is mined from lava flows, crushed and screened, then heated in furnaces to about 1800° F. thus expanding the particles. Perlite is widely used as a rooting medium for leafy cuttings under mist. It has good drainage properties.

6. Water is used for small scale rooting of cuttings of easily propagated species. A great disadvantage is lack of aeration.
7. "Jiffy-mix" is a mixture of peat, vermiculite and perlite, with minor amounts of fertilizer. Excellent for water retention, it is used as a seed germination mix.
8. "0-902" (trade name) propagation blocks are styrofoam blocks impregnated with plant-food nutrients used for propagation of cuttings. (A soilless mix.)
9. "BR-8" blocks are wood-fiber blocks impregnated with plant food. They are used for cuttings and seeds.
10. "Jiffy 7" pellets are pre-shrunk pellets of peat-vermiculite. This medium is used for seeds and woody cuttings; it is commercial prepared at various pH levels.

B. Mixtures to consider in using media.
   1. In propagating cuttings, use:
      a. Two parts sand and 1 part peat moss.
      b. One part sand and 3 parts peat moss.
      c. Sand
      d. Perlite.
      e. A good rooting medium has three functions:
         (1) Holds cuttings in place.
         (2) Provides moisture for cuttings.
         (3) Permits aeration.
   2. In germinating mixes use:
      a. Jiffy Mix as it comes from the package.
      b. Equal parts loam,top soil, peat, and sand or perlite.
      c. One part peat, 1 part medium to coarse sand, and 2 parts soil.
   3. In growing mixes use: 2 parts soil, 1 part peat, and 1 part medium-to-coarse sand.
   4. For foliage plants use:
      a. One-half acid peat moss, one-half soil.
      b. All peat moss.

III. Containers and Beds.

A. For propagation of cuttings.
   1. Raised beds.
      a. Beds should be 2½ to 3½ ft. high, 3½ to 4 ft. in width.
      b. Steam lines or soil heating cable are placed in the bottom.
      c. Beds should be well drained and filled with approximately 7-8 inches of material.
   2. Ground beds.
      a. Ground beds should be raised 8" high.
      b. Ground beds should be made of concrete to seal off the surrounding soil.
      c. Make a "V" bottom for good drainage.
      d. Fill with the propagating medium.

3. Flats.
    a. Flats are constructed of wood, plastic or metal.
    b. Approximately 15" x 20" x 2 3/4" flats are the most popular size.
    c. Flats should be sterilized before using.

B. For seeding.
   1. Some seeding is now being done directly to the growing container.
   2. In most cases seeding is done in flats. Seedlings are then pricked off at very early stage and placed in containers.

C. Sterilization.
   1. All containers, beds and propagating medium should be sterlized before using.
   2. Steam -- raise all parts of the soil medium to a temperature of 180° and maintain for a minimum of one-half hour.
   3. Chemicals can be used to sterilize the soil. They cannot be used around crop plants, and you must wait 2-3 weeks after treatment before planting. Most common materials are methyl bromide, chloropicrin and Vapam.

D. A misting system can be installed over the propagating benches. Generally you will need: a day-night time clock, an interval timer, a solenoid valve, pipe, misting nozzles, and a water strainer.

IV. Securing materials for propagation.

A. When securing stock or mother plants, caution must be exercised to keep the plants free from disease and insects. Discard all stocks after one season. Store all stock in an area other than the propagation area.

B. For many operators, it may be better to buy disease-free rooted cuttings from a reliable dealer.

C. Do not accept gift plants from well-meaning people.

D. Seeds should be purchased from a reliable seed dealer. Be sure you select varieties that are recommended for greenhouse use.

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Things to be brought out by the teacher:
   1. The most common means of plant reproduction in the greenhouse are by seeds and cuttings.

2. A simple explanation of how seeds germinate. (Sexual reproduction.)
3. Explain the ability of higher plants to regenerate and thereby reproduce themselves. (Asexual reproduction.)
4. Differences between herbaceous plants and woody plants in propagation methods.
5. Formation of callus on cuttings.

B. Things to be brought out by class members:
1. Experiences with seed germination.
2. The way soil "feels" when properly prepared.
3. Observations of conditions under which seed has germinated.
4. Experiences with making cuttings.

II. Conclusions

A. Propagating plants is not difficult; there are no "secrets" to success.

B. Care and sanitation must be practiced to be successful.

C. The soil medium is one of the most important factors in success.

D. Always use disease-free material.

E. Seedlings and cuttings must be transplanted soon after root formation and growth starts.

F. All containers, tools, and media must be sterilized.

III. Enrichment Activities

A. In the school greenhouse:
1. Practice seeding.
2. Make cuttings.

B. In the classroom, using a transparent sweater box:
1. Fill with sand.
2. Water thoroughly.
3. Make seedings or cuttings.
4. Cover and watch results.

C. Secure soil media from commercial sources for observation.

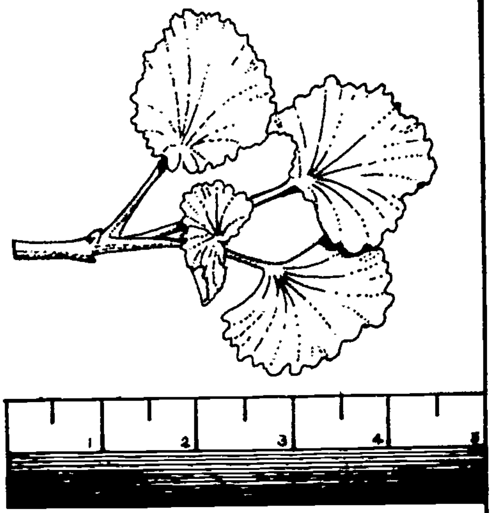
IV. Suggested Teaching Materials

A. References for Lesson 5
1. Flower and Plant Production in the Greenhouse, pp. 115-123.
2. Plant Propagation Principles and Practices, p. 8, 26; pp. 173-174; p. 253; pp. 261-272, 302, 320.
3. Ball Red Book.
4. Grower Talks, January, 1972.

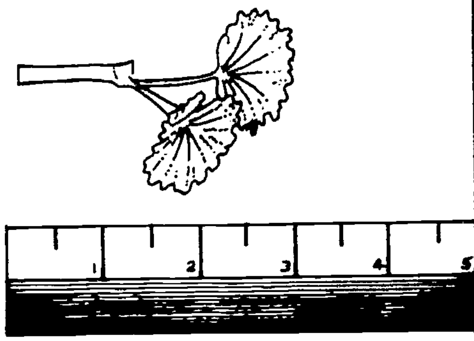
5. Grower Talks, February, 1972.
6. Grower Talks, April, 1972.
7. Greenhou e Crop Production, Teachers Manual.

B. Audio-visuals
   1. Masters
      -1 Types of Cuttings
      -2 Scheduling Plantings (Map)
      -3 Temperatures for Germinating Bedding Plants (Chart)

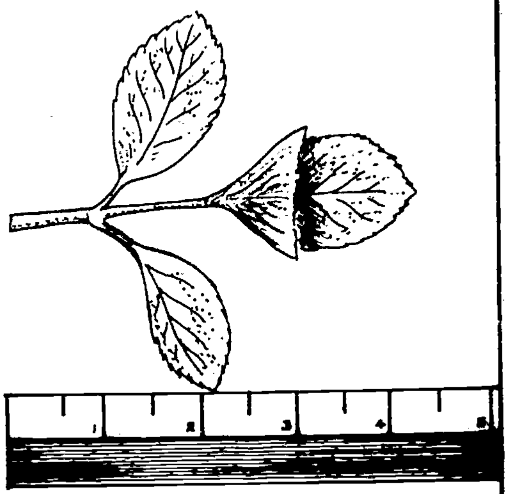
TYPES OF CUTTINGS



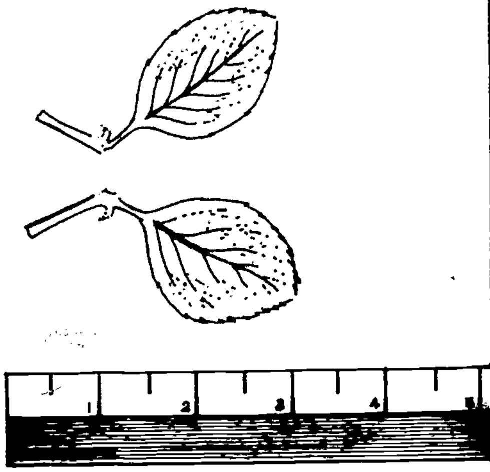
AN UNROOTED GERANIUM STEM TIP CUTTING



AN UNROOTED GERANIUM LEAF BUD CUTTING



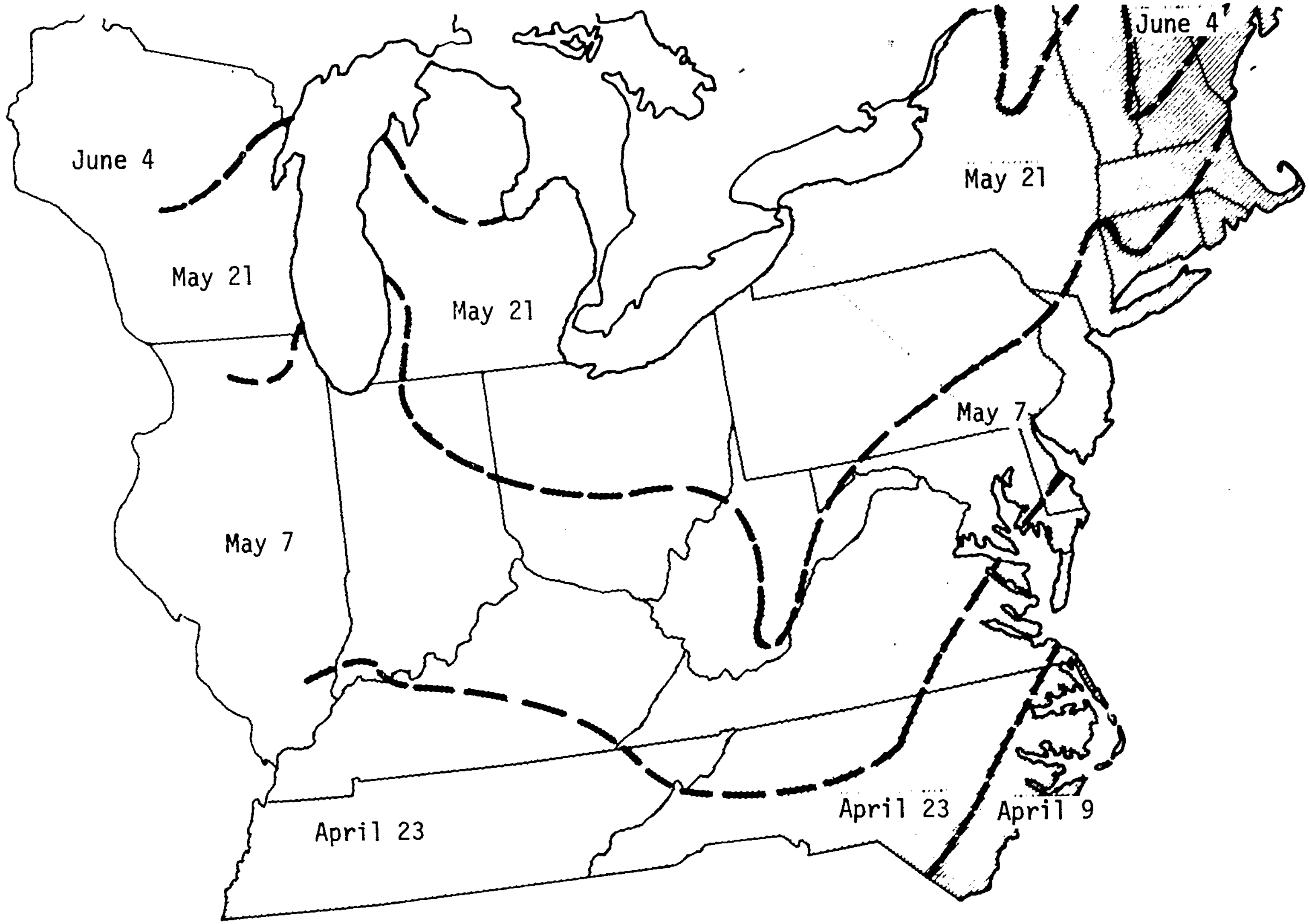
AN UNROOTED HYDRANGEA STEM TIP CUTTING



AN UNROOTED HYDRANGEA LEAF BUD CUTTING

Adult 101-5-1

MARKETING DATES FOR FLOWERS AND VEGETABLES IN THE NORTH EAST



SOURCE: Greenhouse Crop Production, p. 117.

TABLE 1. TEMPERATURES FOR GERMINATION OF BEDDING PLANTS [1]

Plant	Optimum Temperature	Light or Darkness Needed [1]	Days to Germinate
Ageratum	70°	L	5
Aster (Annual)	70°	DL	3
Begonia (Fibrous-Rooted)	70°	L	15
Carnation (Annual)	70°	DL	20
Celosia	70°	DL	10
Coleus	65°	L	10
Dusty Millers			
Centaurea Gymnocarpa	65°	D	10
Others	75°	L	10
Impatien (Sultanas)	70°	L	15
Pansy	65°	D	10
Petunia	70°	L	10
Salvia	70°	L	15
Snapdragon	65°	L	10

[1] Research done by H. M. Gathey, U.S.D.A.

[2] D = seeds germinate best in darkness. L = in light. DL = in either light or darkness.

SOURCE: George J. Ball, Flower Talks

LESSON 6

USING FERTILIZER AND PLANT GROWTH REGULATORS

Objective -- To develop the effective ability of a beginning or experienced greenhouse operator to use plant growth stimulators (fertilizer and hormones) to produce a quality product.

Problem and Analysis -- How should we use plant growth materials (fertilizer and growth regulators) to produce a quality marketable product?

-Fertilizer
- Kinds to use
- Amounts
- Methods of applying
- Preventing salts buildup

-Growth regulators
- Purpose of using
- Kinds to use
- Time
- Methods

Content

I. Fertilizer.

A. There are several factors to be considered in determining the kinds of fertilizer we should use. Many commercial formulas are on the market to suit most of the demand for greenhouse production. These plant foods are offered both in the liquid and dry form. Selection of fertilizer depends upon our goal.

1. If we are producing bedding plants, we are fertilizing a very small area in taking the plants to a first-bloom or bud stage. We are usually producing in an artificial soil mix and we desire a plant with good root development and green, healthy-looking foliage.
2. In production of flowering plants (either pot or cut), we are taking the plant through the full production cycle from seedlings or cuttings to bloom stages with cut flowers produced in ground beds and pot plants in containers. Fertilizing is done on a rather limited area. Our goal is a marketable bloom with good foliage.

3. Vegetable production produced in a ground bed entails being carried through the complete cycle of seeding, growing and producing a marketable product (primarily tomatoes or bibb lettuce).
4. Some growers may produce foliage plants. The fertilizing problem will be basically the same.

B. To make wise fertilizer decisions, consider the following:
   1. Fertilizer may first be divided into two broad categories:
      a. Organic.
         (1) Manure (amounts of plant food supplied is unpredictable).
         (2) Humus (more fully decayed organic matter).
         (3) Leaf mold (recommended for certain tropical plants).
         (4) Corncobs (used as mulch).
         (5) Sawdust (should be at least 20 years old).
         (6) Others which may be available in your region. (Organic materials are used more to develop a good groundbed soil structure than for fertilizer. These materials have physical, chemical and biological effects on soil and should be used with caution.)
      b. Most fertilizer used in greenhouse production is inorganic material and will be available in these forms:
         (1) Regular dry fertilizer. Caution should be exercised when using regular crop fertilizer. Phosphorus and calcium fertilizer should be incorporated in the soil before planting, since they are not highly soluble, and it is good to have them thoroughly mixed into the soil. They may be added to ground beds before each planting. Superphosphate can be mixed in at the rate of 5 pounds per 100 sq. ft. The addition of these materials should be discontinued if a soil test indicates no need. Calcium fertilizers supply calcium to the plants and reduce acidity (pH level generally should be 6.5-7). For the other plant food nutrients, there are more desirable forms of fertilizers.
         (2) Water soluble fertilizer in dry form. Water soluble fertilizer is used if fertilizer is to be supplied to crops through irrigation water. The fertilizer must be soluble to insure even distribution and to prevent clogging of the injectors. Even though some plant food will become insoluble when it contacts minerals found in the soil, it is less likely to cause a build-up of harmful salts when using water-soluble fertilizer. Table 1 lists some commercial names and forms of water soluble fertilizer.

(3) Slightly soluble inorganic type. This type dissolves only when in contact with water. The fertilizer is formulated in such a way that it dissolves in soil moisture in amounts that are generally not harmful to plants. Because this type dissolves slowly it is a source of nutrients for the plants for an extended period of time -- often up to three to four months. Listed in Table 1 are trade names and analyses of slightly soluble inorganic fertilizers.

(4) Soluble inorganic type -- slow release or controlled release -- are encased in physical barriers to prevent water penetration. A wide variety of formulations is found, because the physical barrier is independent of the fertilizer formulation. Some fertilizers are contained in plastic packets and some are coated and pelleted with resins. Packaging and thickness of coatings determine release time. Table 1 lists controlled release fertilizers and analyses.

(5) Liquid water-soluble fertilizer is available in several formulations. Most analyses are low in nitrogen and calcium. When water-soluble materials are used you should watch closely the calcium content of your soil media. Additional nitrogen from other sources will probably have to be applied. On the plus side, you will probably have less sediment in the fertilizer injectors. Liquid forms go into solution easier and stand longer without sedimentation; however, the time required to put on additional nitrogen materials may not be profitable.

C. Amount of fertilizing material to use.
   1. A soil test is imperative.
      a. Adopt the Spurway Test, if possible.
      b. Use the University of Kentucky Soil Testing Service and mark samples "greenhouse soil."
      c. Results of the test may be given in terms of parts per million (PPM) of soluble salts. These are nitrates, chloride sulfates, and carbonates of potassium, calcium and magnesium.
      d. If unfamiliar with fertilizer in terms of PPM, ask the University to make recommendations and explanations on your test.
      e. A Solu-Bridge Soil Tester* may be used to determine the level of soluble salts but it will not tell you which salts are present.

*Trade name.

f. Testing every three or four months will give a general idea of soil fertility level; however, once a month would be more satisfactory.

2. Method of taking samples.
   a. Take samples 6 hours after watering.
   b. Take samples at least 5 days after the last fertilizer application.
   c. Scrape aside mulch and the top $\frac{1}{4}$ inch of soil.
      (1) For bench crops take a full core of soil (top to bottom) from spots equally distributed through the bench area, but not within 2 inches of the edge or end; take 10 cores or more, if possible.
      (2) For potted plants, take samples from top to bottom and from 10 or more pots.
      (3) For stored soil, take samples from 10 or more locations in the pile.
   d. Air dry the soil.
   e. Properly label, identify, and enclose the form requesting the information desired.
   f. Mark as a "greenhouse soil sample."

3. Other pertinent facts.
   a. Cost of fertilizer materials is minor in greenhouse production.
   b. Very small amounts of materials are needed; however, timing is important, and amounts are critical.
   c. Possibly more fertilizer problems are caused by using excessive amounts or the wrong material than by underfertilizing.
   d. During periods of cloudy weather or short days when light emission is low, you should decrease your fertilizer rates.
   e. If controlled-release fertilizers are incorporated into the soil before steaming it will be necessary to leach the soil before planting because fertilizer will be released during the steaming process.
   f. Artificial soil media may be neutral or have no plant food; therefore, it will be necessary to add all of the plant's requirements.
   g. Accurate measures should be used when applying fertilizer (no guesswork and/or "handfuls"). You probably should adopt a weight scale (Tables 2 & 4).

4. Needs of some selected greenhouse crops for fertilizer.
   a. Bedding plants (transplants to market).
      (1) Use 20-20-20 water soluble fertilizer in a 200 PPM constant-feed program (see table 3).
      (2) On a weekly basis, add 2 ounces 20-20-20 dissolved in $2\frac{1}{2}$ gal. water.
      (3) For 2 week intervals, add 4 ounces 20-20-20 dissolved in $12\frac{1}{2}$ gal. water.
      (4) When seeds are germinating, you may use half-strength soluble fertilizer high in phosphorus (9-45-15 for example) and again 2-3 days before transplanting.

b. Pot mums. Constant feed (every watering) using a dilute solution made up of 15-10-30 fertilizer, 18 ounces per gallon with an infector device at 1: 1.100 dilution ratio. Many other formulas are used.

c. Cut mums. Use 20-20-20 soluble fertilizer , 200 PPM N rate in the irrigation water. When buds show color, use high levels of K.

d. Geraniums. Use 15-15-15 in irrigation water at 75 PPM N rate.

e. Foliage plants. Constant feed 20-20-20 at 75 to 100 PPM N rate in irrigation water.

f. Tomatoes. Soil should be tested monthly. The following levels are desirable: pH, 6.5-7.2; N, 20-25 PPM, P, 15-20 PPM; K, 40 to 120 PPM; Ca, 100 to 240 PPM; and Mg, 5 to 10 PPM. A "K" value of 80 is not harmful to many plants.

5. General aspects of fertilizer.

a. If a small operation warrants stocking only a few analyses, choose something similar to a 1-1-1 and 4-1-6 or 4-1-3 water-soluble fertilizer. In controlled release, use 1-1-1.

b. For most plants, soluble salts should be kept below 80 "K."

c. Refer to Table 3 for dilutions.

D. Methods of applying fertilizer.

1. Applied with fertilizer injector.

a. Water soluble fertilizer can be applied during the watering process.

b. Soil should always be moist before applying.

c. Water thoroughly, apply fertilizer through irrigation, and then rinse plants.

d. Constant-feed fertilizer at each watering. Periodically once a week.

(1) Fertilizer injectors are used to apply fertilizer in solution. The dilution ratio varies with the machine. Machine should be checked with a container of known volume.

EXAMPLE FERTILIZER INJECTORS

Device		Ratio	Cost
Hozon -- dilution ratio		1 to 30	$ 3.00 Approx.
Hydrocare		1 to 24	40.00
Commander		1 to 128	110.00
Smith	Various dilutions	1:100-200	575.00

(2) Slow-or controlled-release fertilizer may be thoroughly mixed with soil. This is being used with good results. Follow recommendations given by the manufacturer.

(3) If you choose to use periodic feeding in connection with slow-release fertilizer, the amount put into the soil should be reduced.

(4) Slow release fertilizer may be spread on top of pots or beds. Water thoroughly, and follow manufacturers instructions.

c. Accurate measurements and care should be exercised when applying any fertilizer materials.

d. Correct dilutions may be made and put on beds with a sprinkling can. Be sure you have even distribution.

E. Preventing salts buildup. The salts content in a soil is the total amount of mainly soluble fertilizer present in the soil at a given time; such material as nitrogen, phosphate, potash, and calcium.

1. Causes of salts buildup.
   a. Failure to water soil thoroughly.
   b. Heavy or excessive fertilization.
   c. Too frequent applications of correct dosage.
   d. Field soils occuasionally have high salts level.
   e. Poor drainage.
   f. Irrigation water may have high salts level.
2. To lower salts level:
   a. Use open, porous soil. Water should not stand on the soil. Drainage should be 100%.
   b. Leach the soil.
   c. Add peat moss.
   d. Never let soil dry out.
   e. Test field soil if used.
   f. Check water supply.

II. Growth regulators.

A. Primary reasons for using growth regulators.
1. Used to induce rooting on cuttings.
2. Used to prevent stems of plants from becoming too tall.
3. Used as a chemical pinch on plants.

B. Indolebutyric acid, marketed under such trade names as Rootone* and Hormex*, is used to: increase the percentage of cuttings which form roots, hasten root initiation and increase the number and quality of roots. Instructions are given on containers for use of these materials.

C. B-Nine* is used to control the height of most bedding plants as well as chrysanthemums and hydrangeas. B-Nine should be applied when plants are small. For good control two applications must be made. Foliage is sprayed with a dilute solution of B-Nine. Plants should not be watered for 24 hours after spraying. Instructions concerning strength of dilutions are given on the container label.

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*Trade name.

D. Cycocel* is used to control height of poinsettias. Cycocel is sprayed on the soil, not on foliage. It is applied as a soil drench 2 weeks after the cuttings root. Two applications may be necessary. Cycocel is available as an 11.8% concentrate. Dilute by adding one-fourth of a pint of the material to a 2¼-3" pot. Follow the manufacturer's instructions.

E. Phosfan* is helpful in curtaining height of Easter lilies. and is also used on pot mums.

F. There are some chemicals used for pinching plants. Off-Shoot-O* is a material used for pinching azaleas, privet, yews and junipers.

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Things to be brought out by teacher:
1. Although fertilizer and growth regulators are used in very small amounts, these are critical.
2. Fertilizing in a greenhouse covers a very small area in comparison to field fertilization.
3. This is a case where a little more of a good thing will cause severe damage.
4. Some plant sysptoms which indicate low fertility are actually caused by too much soluble salt.
5. Greenhouse managers must understand soluble salts.
6. The products the grower is after are good bloom and good foliage.
7. A white root indicates a healthy root, while brown indicates an unhealthy condition. This may be caused by too much fertility.

B. Things to be brought out by class members:
1. Differences in fertilizing in a greenhouse and field applications.
2. Symptoms of greenhouse plants that they have observed.
3. Frequency of use, methods of application and kinds of fertilizer used by class members.

II. Conclusions

A. Fertilizer will help determine the economic success or failure of a greenhouse crop.

B. Little cost and small amounts of fertilizer are used, but the effects are great.

C. Fertilizer problems are often caused by applying too much.

*Trade names. No endorsement is intended.

D. Soil testing is essential. It should be economically feasible for any operator to have a Solu-Bridge Soil Tester.

E. Growth regulators are useful. They aid in root growth, height control, more pleasing plant, increased shelf life, delaying marketing periods, pinching, and reducing labor.

III. Enrichment Activities

A. Conduct a tour of a commercial fertilizer plant or distribution centers.

B. Secure and display samples of the various fertilizer compounds.

C. Demonstrate salt buildup in flats and remedial measures to be taken in the event salts do build up.

D. Secure and demonstrate (and perhaps loan to beginning operators) a Solu-Bridge Soil Tester.

E. Demonstrate soil sampling; collect, dry and send in and interpret soil tests for the class.

F. Demonstrate fertilizer application methods.

G. Set up a test of the various growth regulators; have class members take part and observe results.

H. Secure samples for class members from commercial fertilizer companies.

IV. Suggested Teaching Materials

A. References for Lesson 6
1. Plant Propagation Principles and Practices, pp. 305-310.
2. Flower and Plant Production in the Greenhouse, pp. 86-92.
3. Green Thumb, April, 1970.
4. Greenhouse Construction Costs and Production Practices, Ky. Misc. 352.
5. Geiger News, February, 1972.
6. Greenhouse Plant Production, pp. 16-19.
7. Proceedings, Kentucky Greenhouse Flower and Vegetable Grower Conference, 1972.
8. Greenhouse Crop Production, pp. 43-51, 96, 110.
9. Ball Catalogue, 1972.
10. Grower Talks, May, 1972, pp. 8-14.

B. Resource Personnel
1. Cooperative Extension Flower and Vegetable Specialists, University of Kentucky.
2. Sam Whitaker, Eastern Kentucky University.

3. Commercial operators. NOTE: It is doubtful whether they will reveal fertilizer secrets.
4. Personnel of the Soil Testing Laboratory, University of Kentucky.

C. Audio-visuals
   1. Masters
      -1 Examples of Fertilizer Formulations (Table 1)
      -2 Table of Equivalents (Table 2)
      -3 Formulas for Constant Feeding (Table 3)
      -4 Analysis and Application Rates of Common Fertilizers (Table 4)

TABLE 1

EXAMPLES OF FERTILIZER FORMULATIONS

*Peter's Soluble Fertilizer
- 15-15-15 Geranium Special
- 20-20-20 General Purpose
- 15-10-30 Pot Mum
- 15-20-25 Poinsettia Special

*Osmocote Controlled Release
- 18-6-2
- 14-14-14
- 18-9-9

*Mag Amp -- Slow Release
- 7-40-6

*Ra-Rid-Gro -- Water Soluble
- 23-19-17

*Nature's Liquid -- Water Soluble
- 7-14-7
- 3-18-18

Many companies have other formulations available.

*Trade names - no endorsement of any of this material is implied.

TABLE 2

TABLE OF EQUIVALENTS

TEASPOONS
3 tsp. = 1 tbs.

TABLESPOON
2 tbs. - 1/8 cup or 1 fluid ounce
4 tbs. = 1/4 cup or 2 fluid ounces
8 tbs. = 1/2 cup or 1/4 pint
16 tbs. = 1 cup of 1/2 pint

2 cupfulls = 1 pint or 16 fluid ounces
2 pints = 1 quart

DRY WEIGHT
1 ounce = Approximately 2 tablespoons

Each grower* should adopt a system of weights and measures which are comfortable to use and remember.

CONVERTING WEIGHTS
1 ounce = 28.5 grams
1 pound - 453 grams
1 gram = 1000 milligrams
5 milligrams = 1 tablespoon
1 quart = 1 liter
1 gallon = 3.78 liters

NOTE: Measurements in cups and spoons mean level measuring cup and level measuring spoon.

Adult 101-6-2

Table 3

FORMULAS FOR CONSTANT FEEDING

30% Nitrogen Formulas (30-10-10, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE 100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	13.50 oz. (.8437 lb.)	20.25 oz. (1.2656 lb.)	27.00 oz. (1.6875 lb.)
(1:200)	9.00 oz. (.5625 lb.)	13.50 oz. (.8437 lb.)	18.00 oz. (1.125 lb.)
(1:150)	6.75 oz. (.4218 lb.)	10.125 oz.(.6328 lb.)	13.50 oz. (.8437 lb.)
(1:100)	4.50 oz. (.2812 lb.)	6.75 oz. (.4218 lb.)	9.00 oz. (.5625 lb.)
(1:50)	2.25 oz. (.1406 lb.)	3.375 oz.(.2109 lb.)	4.50 oz. (.2812 lb.)
(1:30)	1.35 oz. (.08437 lb.)	2.025 oz.(.1265 lb.)	2.70 oz. (.1687 lb.)
(1:15)	.675 oz.(.04218 lb.)	1.012 oz.(.06327 lb.)	1.35 oz. (.08437 lb.)

25% Nitrogen Formulas (25-5-20, 25-10-10, 25-0-25, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE 100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	16.50 oz. (1.0312 lb.)	24.75 oz. (1.5468 lb.)	33.00 oz. (2.0625 lb.)
(1:200)	11.00 oz. (.6876 lb.)	16.50 oz. (1.0312 lb.)	22.00 oz. (1.375 lb.)
(1:150)	8.25 oz. (.5156 lb.)	12.375 oz.(.7734 lb.)	16.50 oz. (1.0312 lb.)
(1:100)	5.50 oz. (.3437 lb.)	8.25 oz. (.5156 lb.)	11.00 oz. (.6875 lb.)
(1:50)	2.75 oz. (.1718 lb.)	4.125 oz.(.2578 lb.)	5.50 oz. (.3437 lb.)
(1:30)	1.65 oz. (.1031 lb.)	2.475 oz.(.1546 lb.)	3.30 oz. (.2062 lb.)
(1:15)	.825 oz.(.05155 lb.)	1.237 oz.(.07734 lb.)	1.65 oz. (.1031 lb.)

20% Nitrogen Formulas (20-20-20, 20-5-30, 21-7-7, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE 100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	20.25 oz. (1.2656 lb.)	30.375 oz.(1.8984 lb.)	40.50 oz. (2.5312 lb.)
(1:200)	13.50 oz. (.8437 lb.)	20.25 oz. (1.2656 lb.)	27.00 oz. (1.6874 lb.)
(1:150)	10.125 oz.(.6328 lb.)	15.187 oz.(.9492 lb.)	20.25 oz. (1.2656 lb.)
(1:100)	6.75 oz. (.4218 lb.)	10.125 oz.(.6328 lb.)	13.50 oz. (.8437 lb.)
(1:50)	3.375 oz.(.2109 lb.)	5.0675 oz.(.3164 lb.)	6.75 oz. (.4218 lb.)
(1:30)	2.025 oz.(.1265 lb.)	3.037 oz.(.1898 lb.)	4.05 oz. (.2531 lb.)
(1:15)	1.012 oz.(.06327 lb.)	1.518 oz.(.09492 lb.)	2.025 oz.(.1265 lb.)

15% Nitrogen Formulas (15-15-15, 15-30-15, 16-4-12, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE 100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	27.00 oz. (1.6875 lb.)	40.50 oz. (2.5312 lb.)	54.00 oz. (3.3750 lb.)
(1:200)	18.00 oz. (1.1250 lb.)	27.00 oz. (1.6875 lb.)	36.00 oz. (2.2500 lb.)
(1:150)	13.50 oz. (.8437 lb.)	20.25 oz. (1.2656 lb.)	27.00 oz. (1.6875 lb.)
(1:100)	9.00 oz. (.5625 lb.)	13.50 oz. (.8437 lb.)	18.00 oz. (1.1250 lb.)
(1:50)	4.50 oz. (.2812 lb.)	6.75 oz. (.4218 lb.)	9.00 oz. (.5625 lb.)
(1:30)	2.70 oz. (.1687 lb.)	4.05 oz. (.2531 lb.)	5.40 oz. (.3375 lb.)
(1:15)	1.35 oz. (.08437 lb.)	2.025 oz.(.1265 lb.)	2.70 oz. (.1687 lb.)

Use a dosage between 100 ppm and 200 ppm nitrogen. Plant growth and soil tests determine which concentration and formula to use. One-half gallon per square foot is the normal watering rate with constant feeding.

SOURCE: Greenhouse Crop Production, p. 51.

Adult 101-6-3

Table 4

Analysis and Application Rate of Common Fertilizer Materials

Name of Material	Analysis N-P-K	Application Rate Dry	Liquid
Ammonium sulfate $(NH_4)_2SO_4$	20-0-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Sodium nitrate $NaNO_4$	15-0-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Calcium nitrate $Ca(NO_3)_2$	15-0-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Ammonium nitrate	33-0-0	½ lb. per 100 sq.ft.	1 oz. per 5 gal.
Treble-super phosphate $Ca(H_2PO_4O_2)$	0-45-0	2 lbs. per 100 sq.ft.	Insoluble
Superphosphate	0-20-0	5 lbs. per 100 sq.ft.	Insoluble
Urea $CO(NH_2)_2$	46-0-6	½ lb. per 100 sq.ft.	1 oz. per 7 gal.
Mono-ammonium phosphate $NH_4H_2PO_4$	11-48-0	2 lbs. per 100 sq.ft.	1 oz. per 2 gal.
Di-ammonium phosphate (NH_4HPO_4)	21-53-0	1 lb. per 100 sq.ft.	1 oz. per 4 gal.
Potassium nitrate KNO_3	13-0-44	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Potassium sulfate	0-50-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Limestone $CaCO_3$		3 lbs. per 100 sq.ft.	Insoluble
Calcium sulfate $CaSO_4$		2 lbs. per 100 sq.ft.	Insoluble
Ferrous sulfate $FeSO_4$		1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Sulfur S		1 - 2 lbs. per 100 sq.ft.	Insoluble
Magnesium sulfate $MgSO_4$		½ lb. per 100 sq.ft.	1 oz. per 4 gal.

SOURCE: Greenhouse Crop Production, p. 49.

Lesson 7

CONTROLLING GREENHOUSE PESTS

Objective -- To develop the effective ability of greenhouse managers to control greenhouse pests (insects and diseases).

Problem and Analysis -- What methods should we use to control greenhouse pests (insects and diseases)?

-Importance of control
-Preventive methods
-Control methods
-Equipment to use
-Factors in controlling insects and diseases

Content

I. Importance of greenhouse pest control.

A. Bedding plants, potted plants, and cut flowers are more acceptable in the market if they are free from damage and blemishes.

B. Vegetables produced in the greenhouse are more acceptable if they are sound.

C. Entire crops and/or a complete phase of the growing cycle may be lost with a severe insect or disease infestation.

II. Preventative control.

A. The prevention of pests before they attack the plant will reduce the time, effort, and expense of controlling them after they become established.

B. When you see trouble, some damage and probably establishment of the disease or insect will already have taken place.

C. Some things to consider in a preventive program are:
1. Start with clean planting stock.
2. Sterilize soils.
3. Spray or bomb regularly.
4. Use care in ventilating and heating.
5. Practice strict greenhouse sanitation.
6. Be vigilant.

III. Control methods.

A. Failure to control pests may be due to improper spraying methods rather than unsatisfactory materials.

B. If instructions call for repeated applications it is important that these applications be made at correct intervals.

C. Sprays often have to be directed to the bottom (underside) of the leaves.

D. Temperature and air circulation in the greenhouse influence the effectiveness of the control measure.

E. Consider if the material will leave residue on the plant, and if the residue will be undesirable.

F. Many materials are toxic to humans and may damage plants.

G. Directions for application must be carefully followed.

H. Some control methods are:
   1. Aerosol bombs (labor saving).
   2. Vaporizing insecticide from steam lines.
   3. Smoke fumigators.
   4. Fogger (oil-based pesticide).
   5. Dusters.
   6. Sprayer (insecticide mixed with water sprayed under pressure).

IV. Equipment to use.

A. There are several ways to apply insecticides and disease control materials.
   1. The purpose is to get complete coverage of the plant or pest with the correct amount of the material. Many materials used incorrectly are toxic to humans and may harm plants.
   2. A common method of applying materials is by spraying. Control materials are mixed with water and applied under pressure. Types are as follows:
      a. Open tank-type sprayers. Pressure is maintained in the lines and nozzles. This may either be stationary or portable, but each should have an agitator in the tank to keep materials mixed.
      b. Closed pressure sprayer. These units are usually small (3 gals.) and completely portable. If kept clean and with nozzles working correctly, they are adequate for small operations.
      c. Aerosols. Pesticide is mixed with inert gas (propellants) and held under pressure. When the valve is opened, inert gas is released carrying the pesticide into the air. Aerosols are very handy, but cost should be considered.

d. Dusters. Powdered materials are applied with high velocity air in this type. These machines may be powered by a gasoline engine or hand operated; they are available in hand-carried units. (NOTE: at various times, spray units are available at Surplus Properties Division, Frankfort, Kentucky, for use in school greenhouses. Good units can be obtained at very low cost.) Caution! Dusts may leave an undesirable residue on the plant surface.

e. Pressure canister fumigators. Pesticides are mixed with flammable materials in a can. They leave no residue on leaves and are convenient to use, but are comparatively expensive. Not all kinds of pesticides can be applied in this way.

B. The effectiveness of any spraying job will depend upon the diligence of the applicator and his understanding of the insects or diseases being controlled.

C. To keep equipment in good working order it should be thoroughly cleaned after each use. To avoid leaving spray residue in tanks, wash thoroughly with tri-sodium phosphate (at recommended rates) and flush with cold water.

V. Factors in controlling insects and diseases. (See charts at the end of this lesson.)

NOTE: Pesticides which are shown may change as the Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) make changes. Consult your County Extension agent and/or chemical supplier for latest regulations.

Suggestions for Teaching the Lesson

I. Developing the Situation

A. Things to be brought out by the teacher:
1. Very serious economic losses can occur through damage by insects and diseases.
2. Conditions of high humidity and controlled temperature are conducive to development of diseases and insects.
3. Operators can assume that infestations will occur.
4. Insects and diseases must be controlled before damage occurs to foliage, blooms and vegetable products.
5. After some insects or diseases have become established, a control program may not be quick enough to prevent severe damage.

B. Things to be brought out by class members:
1. Difficulties encountered in controlling insects and diseases.
2. Methods they use in controlling pests.

3. Degree of difficulty in controlling certain insects (sucking, chewing, etc.).
4. If they understand the difference in mouth parts, feeding habits, and life cycles if insects.

II. Conclusions

A. Strict sanitation must be practiced in greenhouse production.

B. A preventive program is better than a control program.

C. When using insecticides and fungicides, careful attention must be given to label instructions. Check accuracy on:
   1. Materials to use.
   2. Dilutions.
   3. Applications.

D. To be effective, the right material must be applied by a careful worker with a good understanding of the pest being controlled.

E. Fungicides and insecticides are essential in every greenhouse program.

III. Enrichment Activities

A. Secure pictures and/or samples of the common greenhouse pests; build a display.

B. Develop (with class members) a procedure of preventive action; distribute a copy to each member and publish the list in the local newspaper.

C. Have the Cooperative Extension Entomologist and Plant Pathologist discuss greenhouse pests and needed management practices.

D. Demonstrate control techniques in the school greenhouse.

E. Have a panel of greenhouse operators discuss their programs of pest control.

F. Secure and loan equipment used in insect and disease control to class members.

G. Provide copies of the latest pesticide regulations for class members; have officials from the FDA and EPA speak to the group on regulations and safety precautions.

H. Tour the local chemical supply store.

I. Arrange for group buying of needed chemicals.

IV. Suggested Teaching Materials

A. References for Lesson 7

1. Flower and Plant Production in the Greenhouse, pp. 382-310.
2. Greenhouse Crop Production, pp. 52-63.
3. The Greenhouse Worker, pp. 127-136.
4. Proceedings, Kentucky Greenhouse Flower and Vegetable Growers Conference, 1972, pp. 18-20, 34-41.
5. Grower Talks, March, 1972, pp. 20-21.
6. Grower Talks, April, 1972, pp. 4-12.

B. Resource Personnel

1. Consult local sources.
2. Cooperative Extension Planning Specialists.
3. For specific personnel see VoAg Directory of Resource People in Kentucky.

C. Audio-visuals

1. Masters
   - -1A Common Greenhouse Insects and Control Measures
   - -1B Common Greenhouse Insects and Control Measures
   - -2A Common Greenhouse Disease Problems and Control Measures
   - -2B Common Greenhouse Disease Problems and Control Measures

COMMON GREENHOUSE INSECTS AND CONTROL MEASURES

Insect	Plants Affected	Kind of Damage	Materials for Control	Comments
1. Aphids	1. Almost all plants are affected	1. A. Infest upper portion of plant or younger growth of leaves or buds B. Sucking distortion of tissues C. Black sooty mold may grow from honeydew secreted by aphids	1. A. Cygon* (1 Qt. to 100 gals. water) B. Diazinon* (1 lb. 50% w.p. to 100 gals. water) C. Di-Syston* systemic (15% granular at 1 lb. to 100 sq. ft. or 1 teaspoon to 6" pot) D. Malathion* (25% w.p. 2# to 100 gals. water or 50% E.C. to 100 gals. water) E. Meta-Systox-R (12 ozs. per 100 gals.) F. Thiodan* (1# 50% w.p./100 gals. 3% dust) G. Nicotine Sulphate Smoke Bomb	A. May be used as systemic D. May cause leaf burn F. Fumes should enter under foliage G. Close ventilators
2. Greenhouse White Fly	2. A. Chrysanthemums, Tomatoes, Ageratum, Poinsettias	2. A. Mottling of foilage B. Sucking damage by nymphs C. Infested leaves turn black due to sooty mold	2. A. All material listed for control of aphids (except Malathion) see recommendations for aphids B. Dibrom-8 (Vaporized from steam lines; 1 fluid ounce per 10,000 cubic feet) C. Parathion* (15% w.p. - 1-½ lb. per 100 gals. of water as a spray)	Spray program will be most successful if applied early for prevention; control is difficult in heavy tomato foliage with a severe infestation

*Poisonous to humans

87,88

Insect	Plants Affected	Kind of Damage	Materials for Control	Comments
3. Red Spider Mite (visible with magnifying glass)	3. Chrysanthemums, Roses, Hydrangeas and Carnations	3. A. Sucking B. Leaves turn dull gray-green and are stiff C. In heavy infestations, foliage turns brown and dries and is usually covered with fine webs	3. A. Materials and recommendations listed for aphids B. Pentac w.p., 1½ lbs./ 100 gals. water for resistant red spiders (mostly for roses) C. Aramite 15 w.p., 1¼ lbs./ 100 gals. water D. Tedion (slow acting) E. Kelthane	Population increase rapid in hot dry weather
4. Thrips	4. A. Roses B. Carnations C. Chrysanthemums	4. A. Damaged foliage is white underneath B. Flower bud petals become streaked C. Flower bud disfigured and may fail to open	4. A. Lindane -- 8 ozs. of 25% w.p. to 100 gals water. B. Cygon (See Aphids) C. Malathion (See Aphids) D. Dieldrin* -- 18.5%/quart per 100 gals. Available in aerosols	4. Regular inspection if necessary. Insects are blown in through greenhouse ventilators
5. Root-Knot Nematodes	5. Mums, Begonias, gardenias, cyclamen, tropical foliage plants	5. A. Knots or galls on roots B. Cause malfunction in absorption of water and nutrients	5. A. Soil sterilization B. Vapam and Nemagon are useful as drenches	

*Poisonous to humans

89, 90

COMMON GREENHOUSE DISEASE PROBLEMS AND CONTROL MEASURES

Disease	Plants Affected	Kind of Damage	Materials for Control	Comments
1. Damping-Off	1. Almost all	1. A. Seedling suddenly fall over B. Pre-emergence damage -- seedling killed after germination but before it breaks through soil	I. A. Preventive Measures 1. Steaming soil, containers before seed is sown 2. ¼ to ½ Tsp. Thiram 75%, Captan 75% to each 1 lb. seed packet. Shake. Some plants may be permanently dwarfed by these dusts 3. Gently moving air about 3 ft. above seedlings II. A. Control Measures 1. Captan 2. Thiram 3. Ferbam 4. Terraclor 5. Dexon Follow mfg's recommendation on amounts to apply	Serious problem of greenhouse seedling Preventive measures should be used
2. Botrytis Blight	2. Chrysanthemums, Carnations, Geraniums, Tulips	a. A. Brown dead areas with some yellowing of leaf B. Rot on stems C. May sometimes attack flower petals	2. A. Soil, benches and equipment should be steamed B. Improve air circulation around plants C. Old flowers should be removed from plants. Refuse should be removed from greenhouse D. Zineb 75% w.p. 1½ # per 100 gals. E. Captan 50% w.p. 1½#/100 gals. water F. Botran	2. Leaves touching each other may cause disease; likely to start in wounds or bruises; a fallen flower petal may start the disease

91, 92

Disease	Plants Affected	Kind of Disease	Materials for Control	Comments
3. Powdery Mildew (fungus)	3. Roses Mums Snapdragons	3. Powdery white growth on leaves. Puckering and wrinkling of leaves. Usually occurs on the upper foliage of the plant	3. A. Prevent moisture standing on foliage B. Provide good air circulation C. Continuous operation of sulfur vaporizers D. Karathane E. Actidione P.M.	3. Mildew spores are very light and float easily through the air
4. Stem and Root Rots	Universal		4. Morsodren Dexon Terrachlor	
5. Spots: Flower and Foliage	Universal		5. Captan Ferbam Maneb Phaltan Zineb	
6. Blights and Rusts	Universal		6. Botran Ferbam Maneb Sulphur Zineb	
7. Mildews	Universal		7. Pipron Karathane Sulphur	
8. Sterilization of bulbs and corms	Universal		8. Bichloride of Mercury	

93, 94

APPENDIX

93

MY TEACHING PLAN FOR THIS COURSE

Why I am teaching this course (major learnings or outcomes expected)

____

____

____

____

____

____

ARRANGEMENTS FOR THE COURSE

Session No.	Date	Topic	Clock Hours

This page is for your convenience in planning and rearranging the content of this course to meet local needs and interests. Plan the course as it will be taught in the local school, showing the dates, class session number, topics, and the time in hours allocated to each topic.

TOPIC PLANNING FOR THIS COURSE

Name of Course ____________________

Name of Topic ____________________

Number of Class Meetings Allotted for this Topic ____________________

Teaching Objectives: (Learnings or outcomes for those enrolled)

Major Phases of the Topic: (Problems, jobs, areas, skills, key points, understandings, etc.)

Learning Activities: (Field trips, completing summary forms, panel discussions, demonstrations, etc.)

Teaching Materials Needed: (From resource material list or file)

RESOURCE MATERIALS FOR TEACHING

Unit ______________________ Lesson ______________________

Reference Books	Date Used	File Location
Other References: Bulletins, Magazines, Etc.		
Audio-Visuals: Slides, Filmstrips, Motion Pictures		
Magnetic, Flannel, and Bulletin Boards		
Charts, Maps, Posters		
Transparencies		
Specimens, Models, Mounts		
Human and Community Resources		

Please complete and return to:
Maynard J. Iverson
7 Dickey Hall
University of Kentucky
Lexington, Kentucky 40506

ADULT INSTRUCTIONAL UNIT EVALUATION

-- A Questionnaire for Kentucky VoAg Teachers of Adults

PART I -- GENERAL INFORMATION

How many years of teaching experience do you have? _______

How many years have you taught adults in agriculture? _____

How long has it been since you have taken your last college classwork in agriculture_____; in education _____; (undergraduate, graduate, or non-credit course)? ____________________

What is the highest degree you hold? ____________________

How many teachers are in your department?_________ _______

What age level students do you teach? (✓one)
a) ____high school and adult b)_____adult only

How many other units from the University of Kentucky have you used in your teaching during the past few years?_____

PART II -- UNIT INFORMATION

NAME OF UNIT EVALUATED:____

TYPE OF CLIENTELE TAUGHT: _____Adult Farmer ____Young Farmer
_____Other Adults (please specify)___________________________

Average number attending class ______

Was the interest level _____high? _____moderate? _____low?

How many lessons did you use?_____ How many class periods?_____

Indicate any lesson you added or deleted____

____

____

____

Directions: Place a check mark (✓) in the appropriate left hand column to rate the following components of the unit based on your own observations. A ranking of 5 represents an excellent rating decreasing to a rank of 1 for poor. For the open-ended questions please write on the back if additional space is needed.

Unit Design

5	4	3	2	1	
					General arrangement of parts
					Appropriateness of format for teaching adults
					Length of the unit
					Usefulness of suggestions for using the unit
					Number of lessons
					Order of lessons

Specific comments:____

____

PLEASE CONTINUE ON NEXT PAGE

Objectives in the Unit

5 4 3 2 1

_____ Clearly stated
_____ Reasonable to reach in the allotted time
_____ Relevant to needs of the adult learner
Specific comments:__________

Technical Content

5 4 3 2 1

_____ Usefulness of introductory material
_____ Sufficiently detailed for direct use in class
_____ Related to objectives
_____ Divided into appropriate problem areas
_____ Up-to-date
_____ Accuracy
_____ Reasonably complete
Specific comments:__________

Suggestions for Teaching the Lessons

5 4 3 2 1

_____ Appropriate information for the teacher to bring out
_____ Appropriate items to be secured from class members
_____ Suitable conclusions
_____ Suitability of enrichment activities
Specific comments:__________

Resources and Teaching Aids in the Unit

5 4 3 2 1

_____ Up-to-date
_____ Accessibility to the teacher
_____ Relevance to the unit
_____ Adaptability to the teaching plan
Specific comments:__________

With what parts of the unit do you feel you need additional help?

____ None of them
____ Objectives
____ Content
____ Course organization and planning
____ References
____ Resources and teaching materials
____ Teaching methods
____ Other (Specify)__________

PART III -- GENERAL REACTION

Please indicate any other strengths and weaknesses that you have observed in the unit and any suggestions for improvement, revision, and/or implementation (use the back of this sheet if needed).