NEED

Much progress has been made in developing programs of instruction in ornamental horticulture and greenhouse operation at the secondary level in Kentucky. Vocational agriculture now includes vocational horticulture in the high school and post-secondary curriculums. To effectively conduct such programs, a greenhouse is needed. Greenhouse facilities can also be used to advantage in teaching production agriculture or farming by serving as a laboratory to demonstrate plant responses to light, fertilizer, seed placement, soil preparation, moisture, disease and insect control, and other growth factors. This publication is to assist in planning a greenhouse for use in furthering these programs.

POTENTIAL

Greatly increased family incomes and the rapidly expanding population of America have resulted in an increased demand for many horticultural products and services. The American people have become more aware of their environmental surroundings. They want landscaped private and public property, attractive parks, recreation areas and interstate highways. They have greatly expanded their desire for ornamental shrubs, trees, bedding plants, turf grass, greenhouse vegetables and related products and services. Kentucky's close proximity geographically to some of the nation's largest population centers provides distinct advantages for developing an expanded industry and the occupational opportunities related to it. The availability of labor in many communities provides additional advantages for greenhouse production. The increasing costs and limited supplies of fuel are, however, restricting greenhouse expansion in some areas. Greenhouses for educational purposes must be planned with energy conservation features to demonstrate and teach practical methods.

DEVELOPMENT

Before the horticulture industry can reach its potential in Kentucky, training programs must be expanded at all levels. More people must be made aware of the opportunities. This can best be done at the secondary level. Students receiving such training will be able to enter jobs in horticulture, develop individual businesses, or pursue additional training at the technical and professional levels.

SCHOOL FACILITIES

Good supervised occupational experience must be an integral part of the instructional program in vocational horticulture. This experience must support the course of study by helping students secure learnings and skills important in an occupation. In the past, supervised occupational experience in agriculture has been on home farms. This is not practical to the extent necessary in greenhouse operation. Therefore, school administrators and teachers of agriculture are becoming more aware of the necessity of providing the opportunity for practice. They are requesting help in designing and developing greenhouses and related facilities for teaching horticulture and plant science.

GREENHOUSE USE

The school greenhouse should be used as a student laboratory rather than as a commercial house. It should be used to provide occupational experience through both individual and group projects in general greenhouse operation and in the production of plants considered important in the specific course of study for the area. However, the major portion of a student's occupational experience should be planned outside the greenhouse by "co-oping," working with commercial producers, or in other ways.

The greenhouse should be adapted to the needs of a local program. It will make possible:
* Propagation of plants from seed or preparation of seedflats
* Propagation of plants from softwood cuttings.
* Propagation of nursery stock from hardwood cuttings.
* Bedding plant production—petunias, pansies, ageratum, etc.
* Cut flower production—chrysanthemums, snapdragons, carnations, etc.
* Potted plant production—chrysanthemums, poinsettias, geraniums, etc.
* Vegetable production—tomatoes, lettuce, cucumbers, etc.
* Plant science experiments.

**SITE SELECTION**

Site selection is one of the most important decisions to be made in planning for your teaching facility. The following factors are vital for success with your greenhouse:

- Orient and locate the house for maximum sunlight. The ridge should run east-west for the floor plan shown.
- Place the house for maximum southern exposure and away from any objects such as trees, buildings, etc., which are to the east, south, or west, a distance of at least 3 to 5 times their heights, to minimize shading.
- Locate on a level, well-drained site where surface water will not run into the house.
- Avoid sloping beds or floors in the greenhouse.
- Soil for ground bed culture should be a deep, well-drained, sandy or silt loam. If a location with such soil is not available, soil may be hauled in or certain artificial media methods considered.
- Provide adequate and reliable sources of utilities: water, electricity, and fuel.
- Keep the house away from dirt or gravel play or parking areas where dust is excessive and damage or vandalism may occur more readily.

**SPACE**

The suggested floor plan provides space for most greenhouse growth operations. Soil should be sterilized outside the greenhouse, stored in a protected place, and then brought in as required. Artificial soil media such as peat moss and soil mixes should be handled similarly.

Other materials and supplies such as chemicals, pots, flats, fertilizer, seeds, tools, equipment, etc., should be stored nearby in a drier and more secure location. The high humidity inside a greenhouse rusts tools, cakes powders and fertilizers, and sometimes germinates seeds still in their packages.

If necessary and desired, an added 10- or 12-foot section could be built as a head-house, work area, and storage.
area. Separate fan ventilation and heat would enable this section to be kept dry and more suitable for these functions, and they also would not clutter the greenhouse. Blueprint Kentucky 11.8890-1A shows this option for the rigid-frame greenhouse.

GROUND BEDS

To minimize shading problems, the ground beds are on the south side and the benches on the north. The beds are raised eight inches above ground level by use of six-inch-wide concrete blocks to form a curbing on the edge of the center sidewalk aisle. This has been observed to reduce stepping into or walking through the ground beds by students and others. It also helps to keep the beds neater, and permits bringing in good top soil or using artificial media to fill the bed, which could result in much better growth media than existing site material.

If the underlying soil has poor percolation and drainage, then drain tile may be needed before filling the bed with soil or artificial media.

A variety of crops such as lettuce, tomatoes, cut flowers, field crops, and ornamentals could be grown in these beds. Normally the rows would run across the house and watering would be done by any of several successful methods ranging from furrow-watering between alternate rows of plants to commercial drip-tube, soaker hose, or similar procedures. Potted bedding plants could be placed on a plastic film on the ground and also produced in these beds.

To maintain adequate levels of fertility and organic matter for soil culture, soil in the ground beds should be tested and treated at least annually. The Spurway test is recommended for greenhouse soils as it provides a more complete analysis of nutrient and salt levels. Such tests can be obtained through a county Extension office or sent directly to Department of Regulatory Services, Agricultural Experiment Station Building, University of Kentucky, Lexington, Kentucky, 40546. Use of low salt-forming fertilizers reduces many greenhouse soil problems. The ground beds should be sterilized with steam or a recommended chemical gas annually for disease and nematode control.

Artificial growing media such as mixes of peat moss and vermiculite are becoming more widely used. Specific data and recommendations should be obtained before proceeding extensively with this method.

BENCHES

Bench may be of the open or solid type. The open benches are the least expensive, are well suited for pot production, and permit good air circulation among the pots. A few solid benches filled with soil media are useful for cut flowers and propagating. Sketches of these two types are shown. Solid benches may be built of cement asbestos board or the more rot-resistant woods such as redwood. Preservative-treated wood is excellent provided it has been treated with a suitable water-borne salt-type preserva-

tive (Osmose, or equal). Brush-on treatments are not adequate and therefore not recommended.

Do not use wood containing the oil-base preservatives (creosote, penta, etc.) as these are toxic to plants.

Benches 4 feet wide, which are accessible from both sides, are shown. Those against a wall and accessible from only one side should be limited to approximately 30-inch width because of student arm reach. Bench height (to the top) should be approximately 32 inches to 36 inches.

Solid propagating benches must be equipped with a misting system. This can easily be provided with misting nozzles, an electric solenoid water valve, and a time clock. To prevent spray from wetting aisles and other production areas, clear plastic film is used to erect walls around the propagating bed area and to restrict the mist to that area.

AISLES

A 3- to 4-foot concrete center aisle the full length of the house is essential for a walkway and for equipment movement (wheelbarrow, plant carts, etc.). Aisles between the benches are approximately 30 inches wide to permit students passing each other and to work on both sides simultaneously. Four-inch concrete blocks or bricks can be laid flat to form a walkway. Gravel is not recommended as it scatters and soon gets covered with dirt which cannot be washed off as can be done with the blocks or bricks.

CONSTRUCTION

STRUCTURAL FEATURES

The basic structural requirement of a greenhouse is to provide support for the glazing, wind, and snow loads at a low cost, with the least framing so that shading is minimized. Several commercial houses are designed, fabricated, and available to achieve these requirements.

A rigid-frame design such as the blueprint Kentucky 11.8890-1A also meets these requirements as an economical do-it-yourself project for student construction. See University of Kentucky Cooperative Extension publication AEN-15, "Rigid-Frame Greenhouse Construction." This design is adaptable to commercial or farm fabrication. Use of pressure-treated lumber is recommended to ensure long life and low maintenance. It can serve the functional needs of a school program and also as a model for potential greenhouse operators in the school-patronage area.

FOUNDATION

A solid concrete foundation 12 to 18 inches high, with minimal steel reinforcement, provides adequate lateral and vertical foundation strength and a pleasing appearance around the greenhouse base. Soil splatter inside and outside is also kept off the glazing and structural members. The below-ground footing restricts surface water from seeping into the building. A masonry block foundation with solid concrete footing may be used if construction procedures as shown on plan 8890-1A are followed. Concrete piers at
each frame may be used for economy in these or commercial houses if desired (shown as alternate on Plan Ky.11.8890-1A).

COVERING

A durable covering with several years of serviceable life is recommended for the greenhouse. The annual covering with polyethylene film is often not desired for school locations. Glass is a long life, non-deteriorating glazing of proven serviceability except for hail and vandalism problems, but it requires special structural members for the glass installation and sealing.

Significant improvements in rigid fiberglass reinforced plastics have been made in recent years. Numerous brands of "corrugated fiberglass" are now available at varied prices and qualities. Based on current data and knowledge, only the polyester materials with a 15-percent acrylic additive and "Tedlar" surface seem to be serviceable for more than a few years. All these panels require periodic washing, depending on local contamination. The newer "Tedlar" coated material appears to have much more durability and resistance to ultra-violet degradation than all previous types. The specific type, thickness, and quality of material should be selected for any given house and location only after thoroughly investigating the material's durability, the company's reliability, and the cost. (More information on greenhouse coverings is available from the authors in a separate publication, AEN-10, "Greenhouse Coverings.")

The diffusing property of fiberglass panels keeps one from seeing through the glazing; therefore, students are not distracted by outside activity nor can persons outside observe activities inside the greenhouse.

Glass houses are also available with frosted or similar diffused type glass that provide this same non-see-through feature.

An inner liner of plastic film is recommended, if it can be applied, where fuel economy and reduced condensation drip are desired.

ENVIRONMENT CONTROL

Fully automatic environmental equipment should be used to provide an integrated year-around heating, ventilation, and circulation system for desired plant growth.

The heating requirement for a 28 by 60 foot house with single-layer covering is approximately 250,000 Btu/hr, and for double-layer 150,000 Btu/hr. Heating units may be steam or hot-water types connected to the school's system, or individual gas or oil-fired heaters serving the greenhouse. If the school heating system is placed in standby or operated at a reduced pressure during week-ends or school holidays, the greenhouse should be independently heated.

Provide continuous air circulation within the house equaling 20 to 30 percent of the house volume in cubic feet per minute with a reputable fan circulation and heat distribution method. High-volume A.M.C.A. certified fans rated for a total of 17,000 CFM at 0.10 inch static pressure are recommended for summer ventilation and solar heat control. Gravity and motorized shutters are used for air passage and anti-back-draft functions. Thermostats and proper fusing are necessary for automatic and safe operation of the equipment.

An environmental system composed of gas-fired unit heaters, exhaust fans, shutters, and automatic thermostat control is shown in detail on blueprint 8890-1A.
MATERIALS REQUIRED
28' X 60' RIGID-FRAME GREENHOUSE
(U. Ky. Plan 8890-1A)

STRUCTURAL MATERIAL
Lumber, pressure treated with salt-type preservative, 1500 board feet
Plywood, 1/2 inch exterior, treated as above, 11 sheets
Resorcinal Resin Glue, 2 gallons
Concrete for foundation and aisle, 15 cubic yards
Hardware (steel straps, bolts, nails, hinges, brace wire, etc.)
Paint, exterior white, 3 gallons
Covering, fiberglass, acrylic modified "Tedlar", 4 to 6 ounce, 3400 square feet
Accessories (aluminum nails, seal strips, ridge cover, etc.)

HEATING SYSTEM
Gas-fired unit heaters, 120,000 Btu. per hour output, 2
Thermostats, low voltage for heaters, 2
Vent pipes, caps, etc.

VENTILATION SYSTEM
Fans, two-speed, 8,500 CFM at 0.1 inch static pressure, A.M.C.A. rated, 2
Shutters, gravity, wall-type for fan, 2
Shutters, motorized wall-type for inlets, 2
Thermostats, line voltage for fans, 2

ELECTRICAL, Main entrance panels and basic wiring materials within house

PLUMBING, Basic gas and water piping materials within house

ADDITIONAL REQUIREMENTS
Site improvements, construction labor, running utility services to site, benches, storage cabinets, and other contingencies.

NOTE: Commercial prefabricated or custom built houses of this size with heating and ventilation equipment are available. Check current catalogs for prices and models available.

Other literature & blueprints for greenhouses available from Department of Agricultural Engineering, University of Kentucky.