Teaching Methods

Full Moon Farm Builds High Tunnels: A Case Study in Site Planning for Crop Production Structures

Marci Spaw¹ and
Kimberly A. Williams²

ADDITIONAL INDEX WORDS. greenhouse, construction, orientation, floriculture, vegetables, community supported agriculture, marketing, teaching methodology, decision case

SUMMARY. This decision case presents the issues a grower would face when deciding where to place and how to orient a high tunnel structure on a specific farm site. It provides a tool to teach site planning concepts on a small scale that are easily transferable to issues addressed when planning for construction of all sizes and types

Department of Horticulture, Forestry, and Recreation Resources, Kansas State University, 2021 Throckmorton Plant Sciences Center, Manhattan, KS 66506-5506.

This project was funded by USDA Initiative for Future Agriculture and Food Systems, Farm Efficiency and Profitability Program award no. 2001-52101-11431. This manuscript has been assigned Contribution no. 04-012-J from the Kansas Agricultural Experiment Station (KAES). We gratefully acknowledge Ted Carey (Kansas State University) and Laurie Hodges (University of Nebraska-Lincoln) for their critical review of case study content. We especially thank Jane Drake for her willingness to share her experiences, which became the basis for the case study. The use of trade names in this publication does not imply endorsement by the KAES of products named nor criticism of similar ones not mentioned.

¹Graduate research assistant.

²Associate professor.

of protected-environment structures. In this case, the owner of Full Moon Farm must decide the placement of her high tunnels on a given farm site. Factors to consider include wind, snow, and ice loads as well as structural integrity, labor efficiency, and optimizing light levels. Ultimately, no one solution meets all recommended criteria, so the grower must prioritize the importance of various factors to come to a decision. This case study is intended for use in upper-level undergraduate horticulture courses, and although the principles are broadly applicable to site planning across geographic regions, it is most appropriate for climates above lat. 35°N. In particular, it may prove useful in courses such as greenhouse management and production courses for vegetables, cut flowers, and small fruits, where students assume the role of grower/farmer in the site planning process. This case study is supported by a website version with digital images, digital video, and maps that can be used both inside and outside of the classroom; all are downloadable from the website <http://www.hightunnels.org/planningcasestudy.htm>. The teaching notes present an unorthodox solution to the Full Moon Farm site planning dilemma.

High tunnels are unheated crop production structures that provide more protection than field production but considerably less environmental control than traditional greenhouse structures. High tunnels are typically covered with one layer of plastic and are passively ventilated via rollup side walls and removable end walls. While high tunnels have been used extensively in Asia and Europe, they have only recently been demonstrated as an effective production practice in the United States (Bartok 2000; Lamont et al., 2002; Wells and Loy, 1993).

Because of low capital investment and high returns, high tunnels provide a practical means of entry into intensive crop production for growers who market their produce directly (Wells and Loy, 1993). The use of high tunnels allows the creation of a special marketing niche for market farmers—they set themselves apart by offering locally grown vegetables, cut flowers, and small fruits earlier in the growing season and into the fall after frost. Therefore, the construction of these unheated, plastic-covered structures that provide an extended season is increasing because their use results in additional income in the spring and fall.

After deciding to implement high tunnels, the next challenge is to determine the use, design, placement, and orientation of the structures before construction. This case study illustrates the process a grower would go through and helps students develop problem-solving skills related to site planning for high tunnels and other protected-environment structures. Site planning for high tunnels requires consideration of most of the same factors used to place and orient greenhouses, cold frames, over-wintering structures, and shade and lath houses. The use of high tunnels in this decision case affords the opportunity to introduce the basics of site planning without the overwhelming intricacies of larger, traditional greenhouses. Arguably, better site planning is essential for these non-permanent structures because they are not as structurally sound. Lower cost materials and construction methods make the structures more vulnerable to stresses.

This case study also introduces students to two unique marketing concepts: community supported agriculture (CSA) and crop subscription services. The basis of CSA, which originated in Japan and Switzerland and is now gaining popularity in the United States, is that individuals from the community pledge support to a farm operation by sharing the risks and benefits of locally produced food (DeMuth, 1993). Establishing a subscription service is a way to accomplish CSA: the subscriber agrees to buy a share of each week's harvest. This gives the farmer a guaranteed sale for his or her product at specified retail prices. High tunnel structures allow a farmer to harvest a more consistent crop

during subscription service periods by offering protection against rapidly changing environmental conditions.

This case study is a component of an education module on High Tunnel Site Planning that is posted on the web site www.hightunnels.org (Spaw and Williams, 2004a). The website was created to give growers, educators, and researchers a one-stop source where they can find both original and linked information about all aspects of high tunnel construction and use. In addition to the convenience and accessibility of web-based information, interactive on-line course materials can enhance the learning process (Sistrunk, 1998).

In particular, the education modules and case study offer images and documentation necessary for educators to integrate the concepts of high tunnel technology into their courses, in their geographical area, from their own perspective, and with knowledge of their students' needs. Modules are available to serve a variety of multimedia and educational niches; they include digital images and digital video clips that can be incorporated as short segments into courses that are already taught as a part of horticulture curricula. On the website, the High Tunnel Site Planning Case Study (<http://www.hightunnels.org/planningcasestudy.htm>; Spaw and Williams, 2004b) is enhanced with easily-downloadable images, a 360° panoramic view of the site, video clips from an interview with the grower, and links to such information as maps and reference materials.

The use of case studies, which is a problem-based learning method, enhances the course by contributing to the development of higher-order cognitive skills (Turgeon, 1997). While such methods are effective, they are relatively underutilized in horticulture and related curricula compared to other disciplines, such as business, medicine, and law, where case studies were first developed (Zimmerman, 2002). In a survey conducted in Sept. 2003 of 21 upper-level undergraduate horticulture students enrolled in a greenhouse operations management course at Kansas State University, 37% reported that they have worked through a case study or similar method in courses unrelated to agriculture, but only 15% reported using a case study in horticulture-related courses. A need

exists to develop case studies for use in horticulture curricula.

After completing this decision case, students will have the following skills:

- 1) knowledge about factors and issues that must be considered when determining the placement of a crop production structure;
- 2) appreciation of how all factors interact when determining the site for a crop production structure;
- 3) ability to prioritize importance of factors as they relate to a specific site; and
- 4) confidence in making decisions about how to place and orient high tunnels and other crop production structures.

Ancillary objectives of this case study for the instructor may include:

- 1) introduction of niche marketing concepts such as direct marketing and CSA; and
- 2) discussion of concepts about high tunnel site planning as they apply to other protected-environment structures.

THE DECISION CASE. Note that the case study text and other tools to augment presentation of this decision case are available to students and instructors at: <http://www.hightunnels.org/planningcasestudy.htm> (Spaw and Williams, 2004b). In addition, information for students to use to solve the case study is posted at: <http://www.hightunnels.org/foreducators.htm> (Spaw and Williams, 2004c).

Jane Drake, owner of Full Moon Farm, is an organic vegetable grower in Riley County, Kans. In the past, the outlet for her produce has been local farmers' markets and wholesale sales to small retail markets in the surrounding area. This year Jane intends to start a subscription vegetable service in which local residents sign up to purchase \$12–\$15 of her vegetables each week from mid-May through September. She will not produce crops during the winter.

Jane's main objectives for the construction and use of two new high tunnel structures are season extension, improved plant microclimate, increased farm income by remaining in the market longer, and support of her new marketing strategy evolving around the subscription service. Intended crops for these structures include salad mix, braising mix, and head lettuce in one high tunnel and

tomatoes and cucumbers in the other tunnel. Jane rents a 3-acre (1.2 ha) plot of land in Riley County, Kans., from an organic swine production operator. She and her landlord have a good farming relationship and often work together to solve problems and share equipment.

Because Jane is renting this acreage from season to season, one stipulation is that all structures that she builds must be removable with minimal effort and at a moment's notice; that is, nothing that Jane constructs can be considered permanent. Logically then, she does not want to tie up a large amount of capital in these high tunnels. Therefore, the design that she has chosen is inexpensive, and its structural integrity is comparatively weak.

Jane intends to construct two small, high tunnels, 10 ft wide × 40 ft long (3.0 × 12.2 m), which will each contain two raised beds for production of crops. Jane needs to decide not only where to place her high tunnels on her farm site, but also how to orient them at that spot. There are many factors and issues to consider before she decides on final placement.

The materials that she will use for her high tunnels are PVC pipe frame ribs covered with 3-year, 6-mil [0.006 inch (0.1524 mm)] plastic. The PVC ribs will be spaced at 3-ft intervals and driven 2 ft into the ground. The end walls will be framed with lumber and covered with the same 6-mil plastic. The interior will be ~7 ft high in the middle.

Several farm access roads intersect her plot, which is a convenience in many cases, but these roads are also an important consideration in planning for high tunnel placement. The high tunnels must be far enough from the roads so that no possibility of snagging would occur from farm machinery that travels the road; likewise, machinery should not have to be maneuvered around the tunnels. Machinery is also often pulled along the north tree row.

Other features of the site include a water pump, electricity source, vining plant trellis, and postharvest handling and equipment sheds. Proximity of high tunnel placement to these resources should maximize labor efficiency. As mentioned before, the sheds cannot be permanent structures and are built on skids for quick and easy removal if warranted. This dictates that water lines cannot be permanently plumbed

to the high tunnels. The site plan (Fig. 1) shows all of these structures, as they have already been built. Note that the pump house is a permanent structure maintained by the owner.

Jane has access to this pump house to use the well water for the irrigation of her crops. She uses a thick-walled, rigid, header hose with filters and many outlets so that she can then hook up hoses as needed for drip irrigation or other watering. Jane may occasionally need electricity in her high tunnels. For example, if a cold snap threatens the crops, supplemental heat would be needed. Also, she will routinely use heating pads for germinating seeds.

Riley County is in the northeastern portion of Kansas. The largest city in Riley County is Manhattan, which is home to Kansas State University. On average, the area has more clear sunny days than cloudy ones. Historical data for general climatic conditions (averaged 1971–2000) are: 145 clear days, 126 partly cloudy days, and 94 cloudy days per year. The average yearly precipitation is 34.8 inches (883.9 cm) with snowfall accumulation of 15 inches (38.0 cm) per year. In general, snowfall during one storm is no more than 5 inches.

There are, on average, ~179 frost-free days in the growing season and the last killing frost occurs on 18 Apr. However, 9 May is considered the frost-free date with only a 5% chance that a frost will occur after that date. The average first killing freeze in the fall is 15 Oct. The annual mean temperature is 55 °F (12.8 °C); however, this average does not reveal the extreme cold winters and hot summers that Kansas experiences.

On average, the warmest month is July; however, many Kansans would argue that the first weeks of August are when the most oppressive heat occurs. Temperatures in the summer months are typically near or slightly above 100 °F (37.8 °C). The coldest month on average is January, but February is often when the coldest temperatures for the season are recorded.

Wind is another important climatic factor, especially in agricultural industries. The windiest months are March and April; the calmest are July and August. Average hourly wind velocities in March and April are between 9.8 and 14.3 mph (15.77 and 23.01 km·h⁻¹), the windiest time of day is between 12:00 and 15:00 HR. Keep

Fig. 1. Full Moon Farm Site Plan with no high tunnels depicted. This site plan could be reproduced and distributed to the students as part of a written assignment so that they could indicate precisely on the site plan they would place the high tunnels. This figure is also available as a PDF file on the website <http://www.hightunnels.org/planningcasestudy.htm> (Spaw and Williams, 2004b); 1 inch = 2.5 cm, 20 ft = 6.1 m.

in mind that these are averages and it is not uncommon for typical spring storms to bring 50 mph (80.5 km·h⁻¹) wind gusts.

This is in contrast with the calmest month of August, where wind velocities peak at 10 mph (16.1 km·h⁻¹) and usually hover around 6 mph (9.7 km·h⁻¹). From April to about December, prevailing winds are from the south. Otherwise, northerly winds prevail, with the shift occurring usually in January when winds are often from the northwest. The location of existing tree stands that may serve as

windbreaks on the site are a scraggly hardwood tree row bordering the pump house and other structures along the western access road, and a mature stand of deciduous trees ~50 ft (15.2 m) tall on the north edge of the property.

Jane has spent a considerable amount of time researching her decision. She has read books, articles, and looked on-line to find information. In addition, Jane has talked to growers who use high tunnels and university extension specialists in horticulture. Figure 2 is an example of the final

high tunnels, which casts shadows and diminishes available light, is minimal compared to conventional greenhouse structures.

SNOW AND ICE. Snow and ice are less important factors for two reasons: Jane's production goals do not include winter production; therefore, she could remove the plastic from the PVC ribs in the winter. Also, snow loads in this area of Kansas are typically not heavy enough to warrant snow as a major consideration, especially if the structure is engineered to withstand unavoidable high wind velocities. Ice storms do occasionally hit Kansas and could cause structural damage, even without plastic.

TOPOGRAPHY. Although the site is fairly level, the high tunnels should not be placed in an area that would receive substantial drainage from the farm plot.

Closure: What Jane did

Teaching resources for instructors, including a downloadable digital video interview with Jane explaining what she did and photos of the completed structures, are only available from the unlinked web address <http://www.hightunnels.org/planningcasestudyteachingnotes.htm> (Spaw and Williams, 2004d). This should not be advertised to students because it contains the solution to the decision case.

Jane sited her tunnels in the northwest corner of her site, with a southwest–northeast diagonal orientation (Fig. 3). She felt that this placement offered the most protection available, was close to the water source, and convenient to the equipment shed and cooler. The orientation that she chose does not follow any traditional criteria, but instead is based on her experience with the site. The tunnels were sited in a diagonal orientation to split the force of the wind.

A strong spring storm with reported winds of over 55 mph ($88.5 \text{ km}\cdot\text{h}^{-1}$) did create uplift and removed the plastic on her east tunnel. This said, when asked what she would do differently, Jane responded that she was confident in her site selection and would put the tunnels in the same place, but would use stronger materials in their construction. Specifically, the plastic ends along the sidewalls were buried by 1 ft of soil, and if she were to “do it over again,” Jane would use a more

Fig. 3. Full Moon Farm Site Plan depicting where Jane sited her high tunnels. This site plan can be used for follow-up discussion. This figure is also available as a PDF file on the website <http://www.hightunnels.org/planningcasestudyteachingnotes.htm> (Spaw and Williams, 2004d); 1 inch = 2.5 cm, 20 ft = 6.1 m.

secure plastic attachment technique, such as wiggle wire in an aluminum channel. Also, the PVC rib frame is the least sturdy framing material available. She would have invested in galvanized metal despite the extra expense.

Ultimately, there are other potential site plans that are appropriate. Few, if any, students may suggest the southwest–northeast diagonal orientation of the structures because it is not presented as a possibility in their background reading materials. However, because orientation to maximize light intensity is not critical in this specific case, the diagonal orientation offers

a viable alternative. Other orientations are also correct. For example, an east–west orientation (which is perpendicular to prevailing winds) would allow for maximum ventilation. Or, with an additional capital investment Jane could have installed plastic windbreaks to protect the high tunnels from the south wind. Presenting unexpected solutions helps students become comfortable with “thinking outside the box.”

This interactive case study is a ready-to-use tool to supplement existing horticulture curricula on the subject of site planning for protected environ-

ment structures. In recent years, the concept of “blended learning,” which combines web-based and traditional classroom components, has gained recognition as a way to ensure maximum effectiveness in the classroom (Klein et al., 2003). This case study is a web-based learning resource that can be integrated in numerous ways into current courses; for example, it could be assigned to completely replace a site-planning lecture, either as an in-class or outside-of-class assignment. Students may work individually or in teams, and a group discussion, led by an instructor, may be implemented to reveal solutions and bring closure to the exercise. The flexibility of this case study allows instructors to tailor it to their individual course needs to enhance the learning environment.

Literature cited

- Bartok Jr., J.W. 2000. Greenhouses for homeowners and gardeners. Natural Resource, Agr., and Eng. Serv., Ithaca, N.Y.
- DeMuth, S. 1993. 1993 Community supported agriculture (CSA): An annotated bibliography and resource guide. U.S. Dept. Agr. Alternative Farming Systems Info. Ctr. Agri-Topics Ser. No. AT 93-02.
- Klein, M., D. Sommer, and W. Stucky. 2003. WeBCEIS—A scenario for integrating web-based education into classical classrooms, p. 398–414. In: A. Aggarwal (ed.). Web-based education: Learning from experience. Info. Sci., Hershey, Pa.
- Lamont, W.J., Jr., M.D. Orzolek, E.J. Holcomb, R.M. Crassweller, K. Demchak, E. Burkhardt, L. White, and B. Dye. 2002. Penn State High Tunnel Extension Program. HortTechnology 12(4):732–735.
- Nelson, P.V. 2003. Greenhouse operation and management. 6th ed. Prentice Hall, Upper Saddle River, N.J.
- Simmons, S., M. Reicks, J. Weinsheimer, and J. Joannides. 2000. Learning through uncertainty and controversy. Ctr. for Teaching and Learning Serv., Univ. of Minnesota, St. Paul.
- Sistrunk, L.A. 1998. Using the world wide web for enhancing student learning in future horticultural curricula. HortTechnology 8:29–30.
- Spaw, M. and K.A. Williams. 2004a. Welcome. 12 Mar. 2004. <<http://www.hightunnels.org>>
- Spaw, M. and K.A. Williams. 2004b. Site planning for high tunnel construction. In: For educators, part II planning and construction. 12 Mar. 2004. <<http://www.hightunnels.org/planningcasestudy.htm>>
- Spaw, M. and K.A. Williams. 2004c. Contents. In: For educators. 12 Mar. 2004. <<http://www.hightunnels.org/foreducators.htm>>
- Spaw, M. and K.A. Williams. 2004d. Teaching notes: Site planning for high tunnel construction. 12 Mar. 2004. <<http://www.hightunnels.org/planningcasestudyteachingnotes.htm>>
- Turgeon, A. 1997. Implication of web-based technology for engaging students in a learning society. J. Public Serv. Outreach 2(2):32–37
- Wells, O.S. and J.B. Loy 1993. Rowcovers and high tunnels enhance crop production in the northeastern United States. HortTechnology. 3:92–95.
- Zimmerman, A. 2002. Flexibility and variety in the use of case studies. North Amer. Coll. and Teachers of Agr. J. 46(3):34–40.