Acknowledgements
The second edition of this manual, reviewed and updated in 2012, was developed and published by the University of Minnesota Extension. Funding for this revision was provided through partnership agreements with the Minnesota Department of Agriculture (MDA), the Minnesota Fruit and Vegetable Growers Association (MFVGA) and the United States Department of Agriculture – Risk Management Agency (RMA). These institutions are equal opportunity providers.

Contributing Authors
- Kelley Belina, University of Minnesota
- Eric P. Burkhart, Penn State University
- Karl Foord, University of Minnesota Extension Service
- Beth Gugino, Pennsylvania State University
- Vince Fritz, Southern Research and Outreach Center
- Larry Jacobson, Dept of Bioproducts & Biosystems Engineering
- Pat Johnson, University of Minnesota
- Keith Mann, North Central Research and Outreach Center
- Steve Poppe, University of Minnesota
- Terrance T. Nennich, Sr., University of Minnesota Extension Service
- Carl Rosen, University of Minnesota Extension Service
- Marla Spivak, University of Minnesota
- Emily Tepe, University of Minnesota
- Cathy E. Thomas, Pennsylvania Department of Agriculture
- David Wildung, North Central Research and Outreach Center (Retired)
- Jerry Wright, University of Minnesota Extension Service

Edited by: Terrance T. Nennich, Sr., University of Minnesota Extension Service; and Suzanne Wold-Burkness, University of Minnesota

For additional copies of this manual, contact:
Terrance Nennich
North Central Research and Outreach Center
1861 E Hwy 169
Grand Rapids, MN 55744
218-327-4490
Email: nenni001@umn.edu
# Table of Contents

Introduction to High Tunnel Production ........................................................................... 1  
High Tunnels in Minnesota ................................................................................................. 3  
Risk Management ............................................................................................................... 5  

**STRUCTURES**

Site Selection ..................................................................................................................... 13  
Construction ....................................................................................................................... 15  

**THE HIGH TUNNEL ENVIRONMENT**

Light .................................................................................................................................... 19  
Temperature ........................................................................................................................ 21  
Wind ..................................................................................................................................... 27  
Ventilation ........................................................................................................................... 28  

**CULTURAL PRACTICES**

Crop Layout & Planting Methods ....................................................................................... 33  
Trellising .............................................................................................................................. 37  
Irrigation Considerations & Soil Monitoring Tools ............................................................. 42  
Soil Fertility & Fertigation ................................................................................................. 57  

**CROP PRODUCTION**

Weed Management - Mulches ............................................................................................ 75  
Disease Management ......................................................................................................... 78  
Insect Pest Management .................................................................................................... 89  
Organic Production ........................................................................................................... 110  
Pollination Management .................................................................................................. 116  

**CROPS**

Tomatoes ............................................................................................................................ 119  
Overwintering Garlic ......................................................................................................... 129  
Crop Mixes ......................................................................................................................... 134  
Raspberries & Blackberries ............................................................................................... 143  
Current Research on High Tunnel Fruit Production ......................................................... 155  

Economics and Marketing ................................................................................................. 156  

Copyright © 2012 Regents of the University of Minnesota. All rights reserved. [http://hightunnels.cfans.umn.edu/](http://hightunnels.cfans.umn.edu/)
Dedication to Dr. David Wildung

For 35 years, Dr. David Wildung has been the inspiration and leader of the horticulture program at the University of Minnesota North Central Research and Outreach Center (NCROC). In 1970, when Dave arrived, the horticulture program at NCROC was in its infancy, and now it has grown to encompass 16 acres of fruit, flower, and woody ornamental plantings. Dave’s enthusiasm for the horticulture program and love for his work is always apparent. No matter how busy he may be, he finds the time to answer a question or offer advice. His many awards and his service to the horticultural community illustrate this enthusiasm. Most afternoons Dave can be found out in the field, noting the quality of the strawberries, tasting the first blueberry fruit of the season, looking for disease in the mums, counting the ripening apples in the orchard, and recently doing intensive research in his two new high tunnels. He has commented many times that the NCROC apple orchard is one of his favorite places on earth! Dave’s vision for the horticulture program at NCROC and the University of Minnesota leaves a legacy that will benefit all of us, not only in northern Minnesota but in the larger horticultural community.

A great big thanks, Dave, from all your University of Minnesota colleagues, producers, Master Gardeners and friends!