1. **Know what diseases to expect and potential impact on yield.**

State recommendations for conventional crop production cover diseases occurring in area. Cornell’s is available on-line at: www.nysaes.cornell.edu/recommends/. It includes symptom descriptions and information about management practices appropriate for organic production, such as rotational periods.

2. **Learn about the life cycle of pathogens that could occur.**

Knowing the potential sources for a pathogen, how it spreads, and conditions favoring disease development are essential as avoiding these are the focus of management practices.

3. **Select resistant varieties when possible.**

Unfortunately there are not many vegetable varieties with genetic resistance, and few of these are currently available as organic or untreated seed. See separate list.

4. **Obtain seed that has been tested for seed-borne pathogens when possible.**

Some seed companies have the resources and produce the quantity needed to test seed. Companies lacking these resources should be able to provide information on where the seed was produced, how much scouting is done, and what diseases if any were present.

5. **Consider hot-water treating seed when seed-borne pathogens are a concern.**

Treating seed with hot-water needs to be done just before planting and it needs to be done carefully as there is a small margin between the temperature and length of exposure needed to kill pathogens and the treatment conditions that will kill seeds. Note that the highest temperature seed can tolerate varies among crops and some crops cannot tolerate the temperature needed to kill pathogens. See article.

6. **Practice good sanitation.**

Use new or clean, disinfected planting materials (eg trays for growing transplants and tomato stakes). Clean greenhouses before seeding transplants. Hose-off farm equipment between fields or management unit.

7. **Rotate land away from susceptible crops for soil-borne pathogens.**

Note that rotation is not effective for all soil-borne pathogens, including those able to infect a wide range of plants (white mold fungus), those able to survive saprophytically (*Rhizoctonia*), and those with means to be easily re-introduced into a field (cucurbit powdery mildew fungus). Rotation is most effective for pathogens that survive without hosts short periods (3 years at most). Rotating among crop families is not always sufficient as some pathogens are able to infect crops from different families. For example, *Phytophthora capsici* causes Phytophthora blight in cucurbits, pepper, eggplant, tomato, snap bean, lima bean but not potato. Thus effective use of rotation necessitates knowledge of pathogen biology. Additionally, the unit of land being rotated (preferably an entire field) needs to be
maintained separate from others. Cultivators and other farm equipment used within a unit need to be cleaned before working in another unit, and water should not flow between units following a heavy rainstorm.

8. Separate susceptible crops with later plantings located up-wind of earlier plantings.

Effective distance depends on the mode of pathogen dispersal. Greater distances will be needed when the pathogen is dispersed by wind than splashing water.

9. Use practices that promote soil health.

Amending soil with compost, reducing tillage, growing cover crops, and other practices that improve soil health may promote beneficial microorganisms that control pathogens. Also, a crop with a healthy, large root system will be better able to resist and tolerate root rot pathogens.

10. Maintain healthy plants.

Plants that are healthy but not too luxuriant are thought to be able to resist disease. Research is needed to document observations.

11. Avoid conditions that favor disease development.

Plant when conditions are favorable for plant growth to minimize losses to damping-off. Most fungal and bacterial pathogens causing foliar diseases need a period of free moisture on their host in order to complete the infection process. Wetness periods can be minimized by planting rows parallel to the prevailing wind direction, avoiding dense plant populations, managing weeds to maintain good air movement, trellising plants when possible, and using trickle irrigation or overhead irrigation when plants are dry and a good drying period will follow. Wet soils are favorable for some soil-borne fungal pathogens, notably *Pythium* and *Phytophthora* species. Select fields with soil that drains well and use raised beds when growing susceptible crops.

12. Use disease forecasting systems to determine when diseases are likely to occur.

There are 2 basic types of systems. The forecasting system for cucurbit downy mildew (pathogen survives only on living host tissue) in the eastern USA uses information on regional disease occurrence, favorability of conditions for spore production, release, and movement by wind from where the disease is occurring, plus favorability of conditions for disease development where the spores are predicted to land. This system is free to use. www.ces.ncsu.edu/depts/pp/cucurbit/

Other systems assume the pathogen is present and use field data on daily temperature and moisture (RH, leaf wetness, and/or rainfall) to predict the favorability of these conditions for disease development and to recommend when fungicide applications are needed. FAST and TOM-CAST developed for early blight in tomato have proved useful for other diseases (e.g. leaf blights in carrot). WISDOM considers crop maturity when forecasting early blight in potato. BLITECAST is for late blight. Sensors, data loggers, and software needed to collect on-farm data and run forecasting systems can be purchased from companies such as Spectrum Technologies (www.specmeters.com/). Regional forecasting programs have been
run by extension in some states. Another option is to subscribe to services that provide weather and disease as well as other pest predictions at the farm scale (www.skybit.com).

13. **Manage weeds and insects that can carry pathogens.**

Weeds can be alternate hosts for some pathogens as well as contributing to favorable conditions for disease development by increasing humidity. Insects that vector pathogens include aphids (viruses), thrips (TSWV), leafhoppers (aster yellows), and cucumber beetles (bacterial wilt). Controlling these insects is often the only way to control the pathogen.

14. **Destroy volunteer crop plants.**

These can harbor pathogens.

15. **Avoid moving pathogens during farming operations.**

Bacteria and splash-dispersed fungal spores are often present on foliage when plants are wet and can be easily moved when plants are handled by farm workers or when a high pressure sprayer is used. Workers pruning tomatoes should routinely clean hands, preferably by wearing plastic gloves which can be dipped into a disinfectant.

16. **Examine plants weekly for disease symptoms and for insect vectors.**

Thorough examination is needed to detect diseases near the onset of development when applying rescue treatments can slow development.

17. **Minimize the opportunity for soil-borne pathogens to be splash-dispersed to crops.**

Covering soil with an organic or plastic mulch provides a barrier between pathogens in soil and the crop. Hairy vetch mulch has also been shown to stimulate plant defenses in tomato. Trellising tomatoes greatly reduces number of fruit in contact with soil.

18. **Accurately diagnose disease problems.**

If the first symptoms observed are not sufficient to make a definitive diagnosis, examine other plant parts for symptoms and other plants to determine distribution. Submit samples to state diagnostic lab if still in doubt.

19. **Apply approved rescue treatments if yield likely to be affected without this intervention and disease is at early stage in development.**

Rescue treatments can be effective when started very early in disease development. Accurate diagnosis is critical.

20. **Maintain records of disease occurrence, impact, and efficacy of management practices used.**

These records will be invaluable in the future.

21. **Incorporate diseased crop debris after harvest.**

Crop debris is broken down faster by microbes when in soil than left on the surface, thus reducing the survival time of pathogens that can only survive in crop debris.
Guidelines for Managing Vegetable Diseases with Focus on Biology
Meg McGrath, Cornell University, LIHREC, Riverhead, NY

I. Requirements for Disease
   1. Pathogen (disease-causing organism)
   2. Susceptible plant
   3. Favorable environmental conditions
   4. Time

II. Management of Diseases
   Focus on Prevention. Integrated approach. No cures.

III. Components of Disease Cycle to Target in Managing
   A. Sources of Disease-causing Organisms
      1. Infested debris
      2. Infested seed or infected transplants
      3. Live in soil in absence of host
      4. Alternate hosts (weeds, other crops)
      5. Plants in another location
      6. Survival structures (ex. fungal sclerotia, nematode cysts)
      7. Insect vectors

   B. Mechanisms for Dispersal
      1. Wind
      2. Rain and irrigation
      3. Soil
      4. Seed
      5. Insects and other vectors
      6. Humans (handling, machinery)

IV. Management Practices
   A. Control the Source of Pathogens
      1. Select certified 'disease-free' seed and transplants.
      2. Treat seed with hot water.
      3. Rotate land to a nonsusceptible crop for at least one year (longer for some diseases).
      4. Control weeds.
      5. Control insect vectors.
      6. Plant when pathogen does not normally occur.
      7. Exclude exotic pathogens.
      8. Destroy infected plants when disease is detected early, few plants are affected, and the pathogen likely has no opportunity for extensive spread.
      9. Amending soil with compost might increase activity of beneficial microorganisms.

B. Minimize the Opportunity for Dispersal
   1. Cover soil with mulch.
   2. Do not handle plants when they are wet.
   3. Disinfect pruning and cutting tools frequently.
   4. Physically separate plantings of similar crops.

C. Reduce Plant Susceptibility
   1. Select disease resistant varieties.
   2. Maintain plant vigor through proper nutrition, watering, weed control, etc. But avoid luxuriant growth.
   3. Plant when temperatures are favorable for germination and growth of the plant.
   4. Hairy vetch mulch has been shown to induce resistance in tomato.

D. Make the Environment Less Favorable for Disease Development
   1. Locate plants where there is good air movement, avoid shady areas, and plant rows parallel to the prevailing wind direction.
   2. Use raised beds.
   3. Plant when conditions are not favorable for disease.
   4. Grow a diversity of crops.
   5. Stake or trellis plants when possible.
   6. Avoid a dense plant population.
   7. Control weeds.
   8. Provide adequate soil moisture - do not over or under water.
   9. Use trickle irrigation or use sprinkle irrigation in morning before a good drying period.

E. Examine Plants Weekly. Identify Cause of Any Problems.

F. Suppress Disease Development
   1. Rescue treatments. Most effective when used preventively or at the first sign of disease.