Chapter 4: Spinach Production

Spinach Production

This handbook is directed toward baby leaf spinach. The production of the spinach crop is separated into two growing areas. Seeds are started in a germination area where they germinate for 2 days. They should be shaded from full sun on the first day after germination, but can then be exposed to full light (17 mol/m^2/d) or slightly greater. On Day 14 the plants are harvested by shearing the crop above the media. Do not attempt a second harvest with the same plants as this will eventually allow pathogens in the nutrient solution to build to a lethal level and destroy both the plant material in the pond and future plant material placed in the same solution.

Germination Area Stage

Germination Area stage is scheduled for production days 0-2 and may occur in a growth chamber or nursery area in the greenhouse.

Sowing

Production begins with the making of the germination media. Media should be moistened to an optimal moisture before sowing occurs. Cornell mix or a commercial product that approximates the mixture of peat/perlite in CU mix should be used. Fill the flat with media. Use a dibble to compress media (Figure 11). Place seed on top of media by hand or with automatic seeder (vacuum seeder, Figure 12). Add additional media and compact. Place in humid environment for germination.

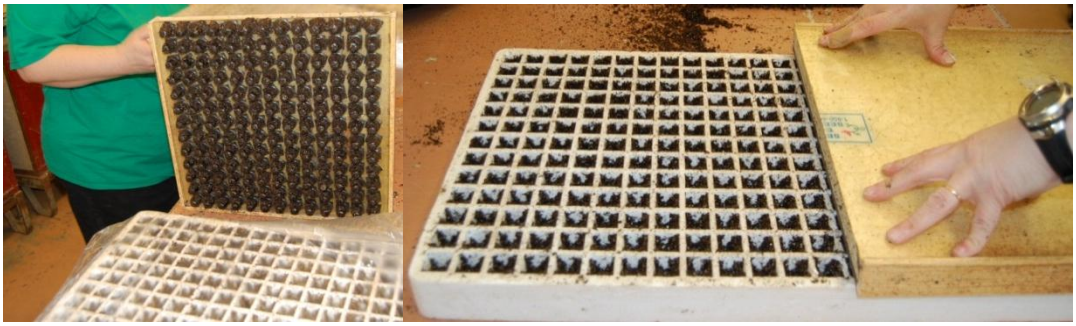

Figure 1. Underside of dibble on left and dibble compressing soil on right.

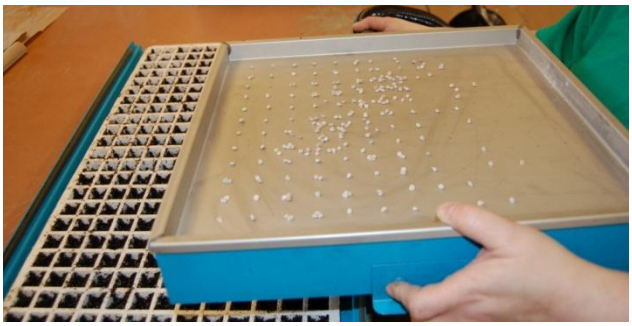

Figure 2. Pelleted seed being spread on a vacuum seeder.

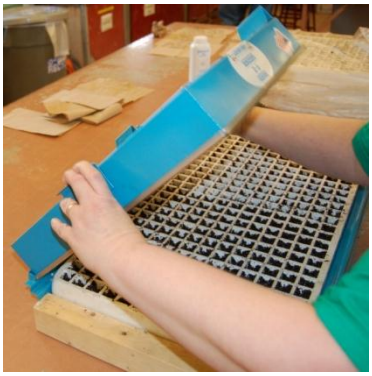

Figure 3. Seed adhered to vacuum seeder plate being inverted over flat.

Figure 4.Pelleted seed on dibbled media ready for additional media to be added.

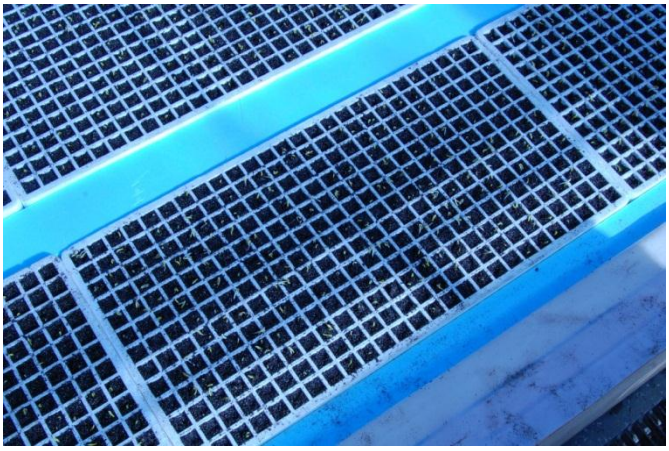

Figure 5. Newly germinated seedlings just after floating in the pond. Note the cotyledons just poking through media.

We recommend an expanded polystyrene plug tray for baby spinach production. These roughly 0.52 square meter trays come in many different densities (for example, arrays of 12 x 24, 14 x 28, 13 x 26) and we have trialed densities between 1000-3000 plants per square meter. We find that a plug tray that allows 1500 plants per square meter is optimal. The two companies whose trays we have experience are Speedling (1.75" deep) and Beaver Plastics (2.5" deep). Custom trays can be ordered and manufactured such that every other cell is Styrofoam so that only half the media is needed and cells would be double seeded. Please note that if trays are double seeded they need to be harvested when a little smaller or plants become brittle.

Trays are filled with a peat/perlite mixture, we use Sungro Redi-Earth seedling germination mix. The moisture content of this media is critical to seedling germination. Please note that media CANNOT be re-used because of the risk of disease. Also note that media cannot be autoclaved to reduce disease risk because that process damages the physical properties of the media. Media should be moistened before seeding (3:1 water: media for peat-based) to ensure proper moisture content and consistent and predictable germination. Both the moisture and air content of the media are critical for uniform and consistent germination. Attempting to add moisture to the top or bottom of the flats will often result in uneven germination.

Trays must be kept in a high-humidity environment until plants emerge from the soil. Roots will exit the bottom of the flat before the shoots emerge from the top. The time this takes can change based on the temperature the trays are kept in. We suggest a temperature range between 22 and 26C and humidity as close to 100% as possible. Many different ways may be used to create the high humidity condition including putting plastic sheeting on top of stacked floats or adding humidity to the germination chamber.

Seeding depth

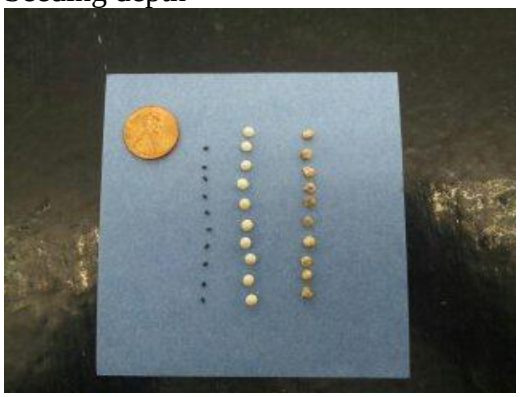

Figure 6. Comparitive size of seeds: Basil, pelleted basil, spinach (left to right).

Spinach seed is large which makes it easy to handle (Figure 16). Seeds must be planted at least ½" deep so that the outer covering of the seed (called the pericarp) is removed by the friction of the media as the hypocotyl emerges.

When trays are placed into a temperature controlled chamber until seedling emergence careful attention should be given so that temperature stratification (ex. Warmer at top and bottom of

rack, see Figure 3) does not occur. To help avoid this issue, allow all trays to arrive at an even temperature before placing in the germination chamber.

Light should be provided at a minimum intensity of 100 µmol/m^2/s to prevent stretching after 24 hours.

Float the flats in the pond after cotyledons appear (Figure 15). We recommend a two pond system so that the growth of the product is faster than the reproduction of the pathogen. If the spinach is allowed to remain in the same pond for the entire crop cycle, the asexual form of the pathogen can reproduce and spread to the younger plants. Because the nutrient solution is not changed regularly, eventually concentrations of the pathogen will be large enough to infect young plants and kill them before they reach maturity.

Monitor pH and EC daily and DO not less than once per week. Harvesting is conducted on day 16 and is often performed manually with scissors or an automatic knife. Commercial harvesting machines are not widely available.

Chapter 5: Packaging and Post-Harvest Storage

Packaging can be a significant cost and many grocery stores are requesting clamshell style hard plastic packaging. The type of packaging will affect the shelf life of the product. Re-sealable bags are the most inexpensive packaging option.

After being packaged, the spinach should be stored at 40F (4C). Penn State researchers have performed experiments investigating the

Chapter 6: Crop Health

Disease

As mentioned previously, hydroponic spinach is particularly susceptible to a water-borne pathogen called *Pythium aphanadermatum* that will attack the crop roots slowing growth and eventually killing the plants. A review of the life cycle of this pathogen is beyond the scope of this handbook but an excellent and classic resource is Plant Pathology by G.N. Agrios. We feel that hydroponic spinach can be grown successfully by following the protocol outlined above that includes controlling the temperature of the pond water, duration of the crop in each pond, and daily light integral. You must keep the crop rapidly growing by providing adequate light, nutrients, and other environmental conditions at all times.

If root disease does occur, the ponds and solution tanks should be drained and the crop sacrificed. The ponds and tanks should be cleaned with a 2% bleach solution. It is possible the disease started in the Germination Area, and that area, including the benches and solution tanks, should be cleaned, as well.

Wash the Styrofoam floats, trays, and other equipment with a 2% bleach solution (sodium hypochlorite). The equipment should be washed between each use, to prevent the spread of disease.

Do not bring other plant material or soil into the greenhouse. This material may contain pests and pathogens likely to infect your crop. **Keep visitors to the greenhouse to a minimum** or allow them to view the production area from the outside of the greenhouse only.

Keep the solution tanks shaded in some manner. Algae flourish in wet, well-lit locations, and the solution tank is ideal for algal growth. Shading the tanks, input and output pipes, and other "wet" equipment will inhibit algal growth. The algae will not harm the crop directly, but may act to weaken the crop to potential disease.

Pests

Pests in hydroponic spinach production have not been a major problem. Fast plant growth rates make pest population establishment difficult. With continuous crop production, pest populations may have the opportunity to establish themselves. Precautions can be taken to exclude pests from the facility, such as screening potential entry points (ventilation inlets). Keeping the grass and weeds mowed outside the greenhouse or removing all vegetation entirely can reduce pest pressure inside the greenhouse. Few pesticides have been labeled for use on greenhouse vegetables. Biological insect control is a viable but less used alternative.