UNIVERSITY OF GEORGIA
EXTENSION

How to Grow Greenhouse Spinach During Georgia Summers Using Hydroponics

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Introduction

Spinach (*Spinacia oleracea*) is an important nutrient-dense leafy green and its annual per capita consumption has significantly increased over the last decade. Most fresh market spinach comes from field production, which is labor-intensive and expensive for weed management, harvest, and other field maintenance. Controlled environment agriculture (CEA) offers a supplemental way to produce spinach with many advantages, such as reducing labor costs, increasing production per unit area, and providing an extended growing cycle compared to field production. This publication outlines production strategies for growing summer spinach hydroponically in a controlled environment.

Spinach is a cool-season crop. The optimal temperatures are 65–70 °F (18–21 °C) for spinach seed germination and 60–77 °F (15–25 °C) for spinach growth. Spinach is typically seeded during early spring (February–March) or early fall (September–October). Growers in the southern U.S. often skip field production in summer because of high temperatures, insects, diseases, and weed pressure. High temperatures and increased solar radiation (light intensity) during summer can result in bolting (flowering) and sunburn in spinach (Figure 1), which can significantly reduce its marketable yield.

Figure 1. Problems With Georgia-Grown Spinach in the Summer. A spinach plant that bolted (left) because of high air temperature. A spinach plant with sunburn symptoms (right) from high light intensity.

Given that the maximum air temperature inside a controlled-environment greenhouse during the summer could easily reach 90–95 °F (32–35 °C; see Figure 2), the question arises: Is it still possible to grow spinach hydroponically within such an environment? The answer is yes.

In addition to using shade cloth to shield the greenhouse from excessive heat and intense light, success with summer greenhouse spinach production in Georgia is possible with three additional considerations: 1) seed germination improvement, 2) heat-tolerant cultivar selection, and 3) optimal hydroponic system implementation. We will cover each of these topics in detail.

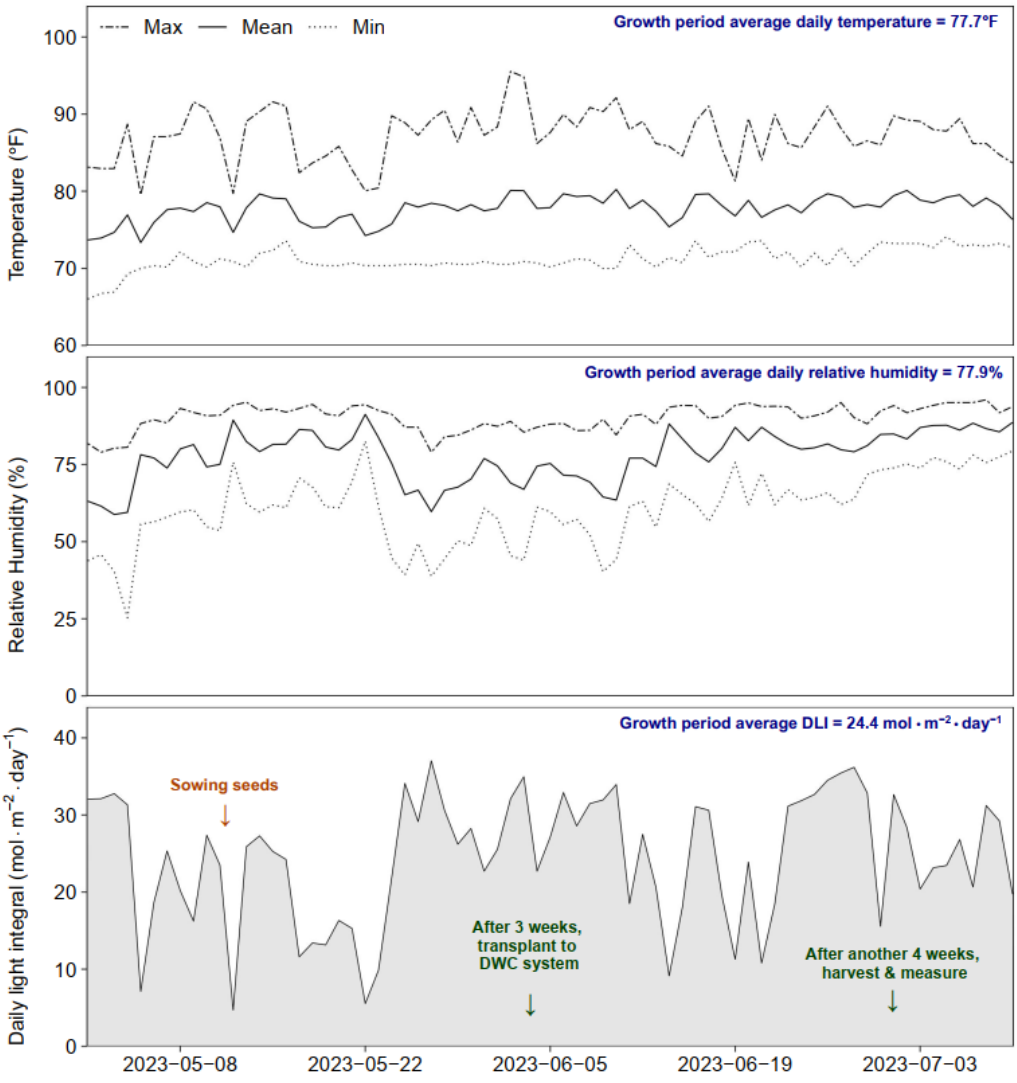


Figure 2. An Example of Climate Data From a Greenhouse Located in Griffin, GA, During Early Summer.

Improve Spinach Seed Germination

Spinach seed germination is normally low and slow compared to other leafy greens. Poor germination and uneven growth will cause a noticeable reduction in crop growth and yield. Especially during the summer, placing germination trays inside the greenhouse could result in much lower and less consistent spinach seed germination (Figure 3).

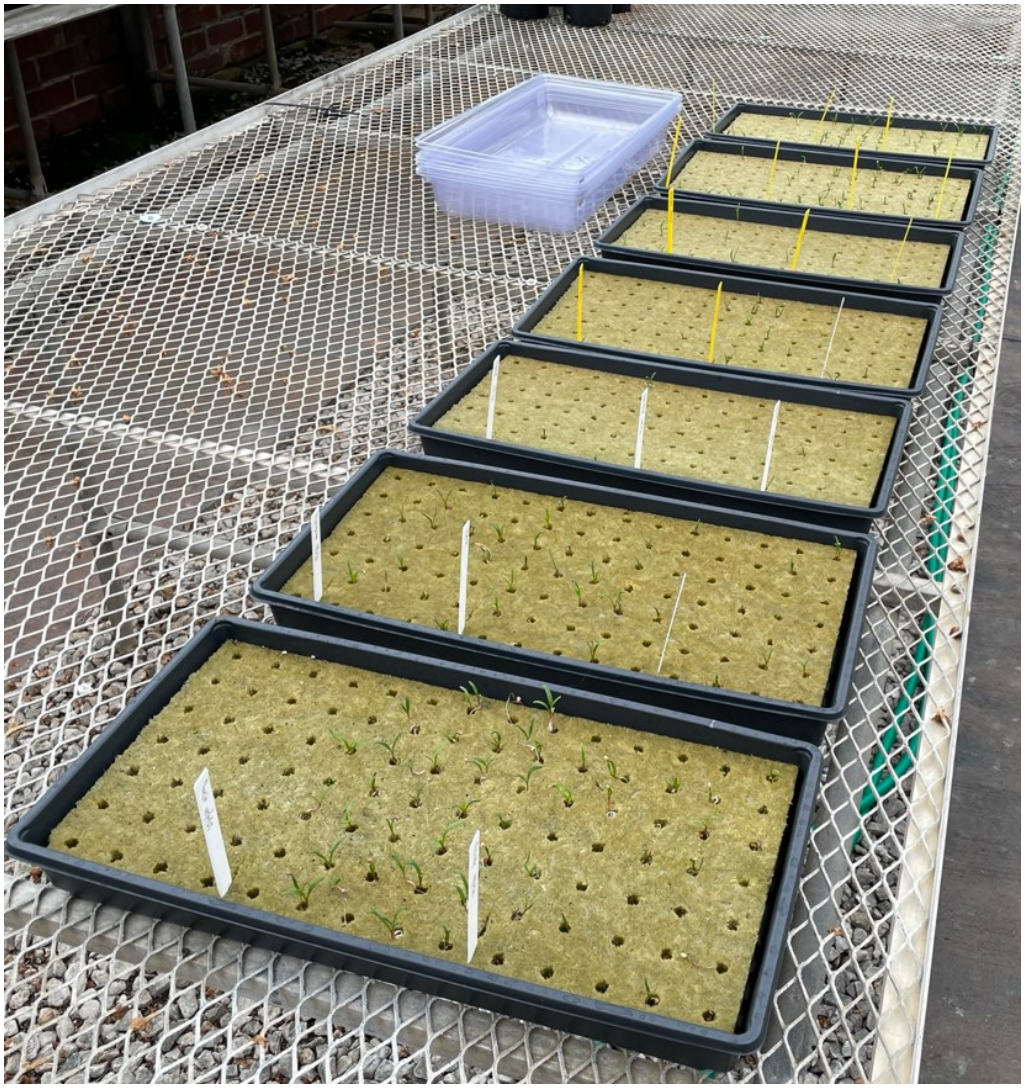


Figure 3. Inconsistent and Low Germination Rates of Spinach Seeds Sown in the Greenhouse. There appear to be differences between spinach cultivars.

Table 1 shows the germination rates from 22 commercial spinach cultivars that were directly seeded during the summer season inside a greenhouse. ‘Banjo’ and ‘Sunangel’ exhibited germination rates higher than 50%, but most spinach cultivars displayed a low germination rate.

Table 1. Seed Germination Rates of Spinach Cultivars Tested in Greenhouse Production During Summer.

Cultivar	Germination rate (%)
'Ashley'	31
'Banjo'	66
'C2-606'	0
'Dallas'	16
'Edna'	30
'Flamingo Improved'	41
'Gorilla RZ'	2
'Green Beret'	4
'Kiowa'	10
'Kona'	7
'Lizard'	32
'Magnetic'	10
'Mandolin'	2
'Patton'	4
'Platypus'	13
'Red Snapper'	18
'Red Tabby'	32
'Seaside'	39
'Sioux'	7
'Space'	37
'Sunangel'	57
'SV3580VC'	13

Priming Methods

Several priming methods can be used to improve the germination of spinach seeds.

1. Soak the seeds in water, or a 0.3% (v/v mixture) hydrogen peroxide (H_2O_2) solution, for 18 hr, then transfer the seeds into rockwool germination slabs that have been pre-soaked with water.
2. Soak the seeds in a 0.5% sodium hypochlorite (NaOCl) solution for 4 hr, leach in water for 15 hr, and then soak in a 0.3% H_2O_2 solution until germination occurs.
3. Use acid scarification (e.g., soaking in 36 N sulfuric acid for 30 min), followed by priming in a polyethylene glycol (PEG) solution.
   Please follow the safety procedures for using strong acid as provided in UGA Research Laboratory Safety Library (https://research.uga.edu/docs/units/safety/manuals/Chemical-Laboratory-Safety-

Manual.pdf). *Note: Neither UGA nor the authors are liable to any party for any direct, indirect, implied, punitive, special, incidental, or other consequential damages arising directly or indirectly from any use of the acid scarification.*

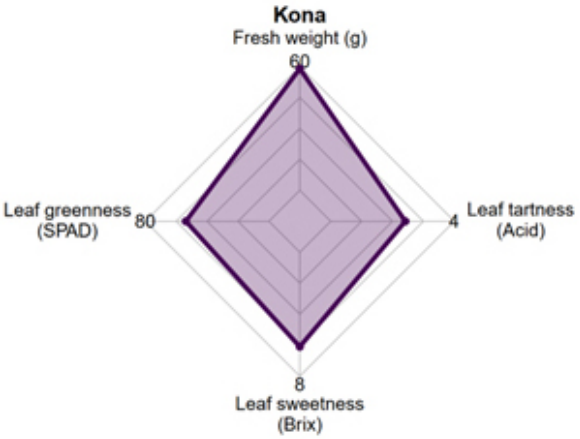
All these methods have been shown to increase the spinach seed germination rate, although the effectiveness depends on the spinach cultivar and seed coating methods.

Select Appropriate Spinach Cultivar for Summer Production

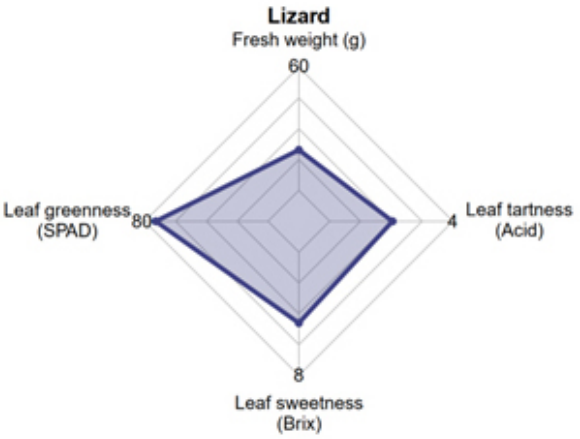
Resistance to bolting during summer production is very important. We have tested many commercial spinach cultivars, and several cultivars have shown enough resistance to bolting that they should be considered for summer production.

We have measured some basic parameters for these cultivars, including fresh yield, leaf color performance, and taste (Figure 4). Leaf greenness is represented by the leaf chlorophyll content, which is measured by a handheld chlorophyll content meter with the soil plant analysis development (SPAD) value as a reference. A higher leaf SPAD value means a darker green color, which could be an important indicator for leaf color appearance. Leaf sweetness (also known as soluble solids content with Brix as the unit level) and tartness (using acidity as the unit level) are parameters related to leaf-taste quality and are measured by a Brix-acid meter that uses *refractometry* (light refraction) and *electroconductivity* (electrical current).

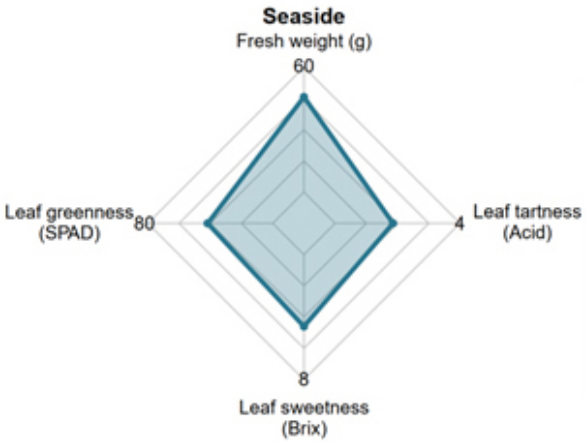
Kona



Lizard



Seaside



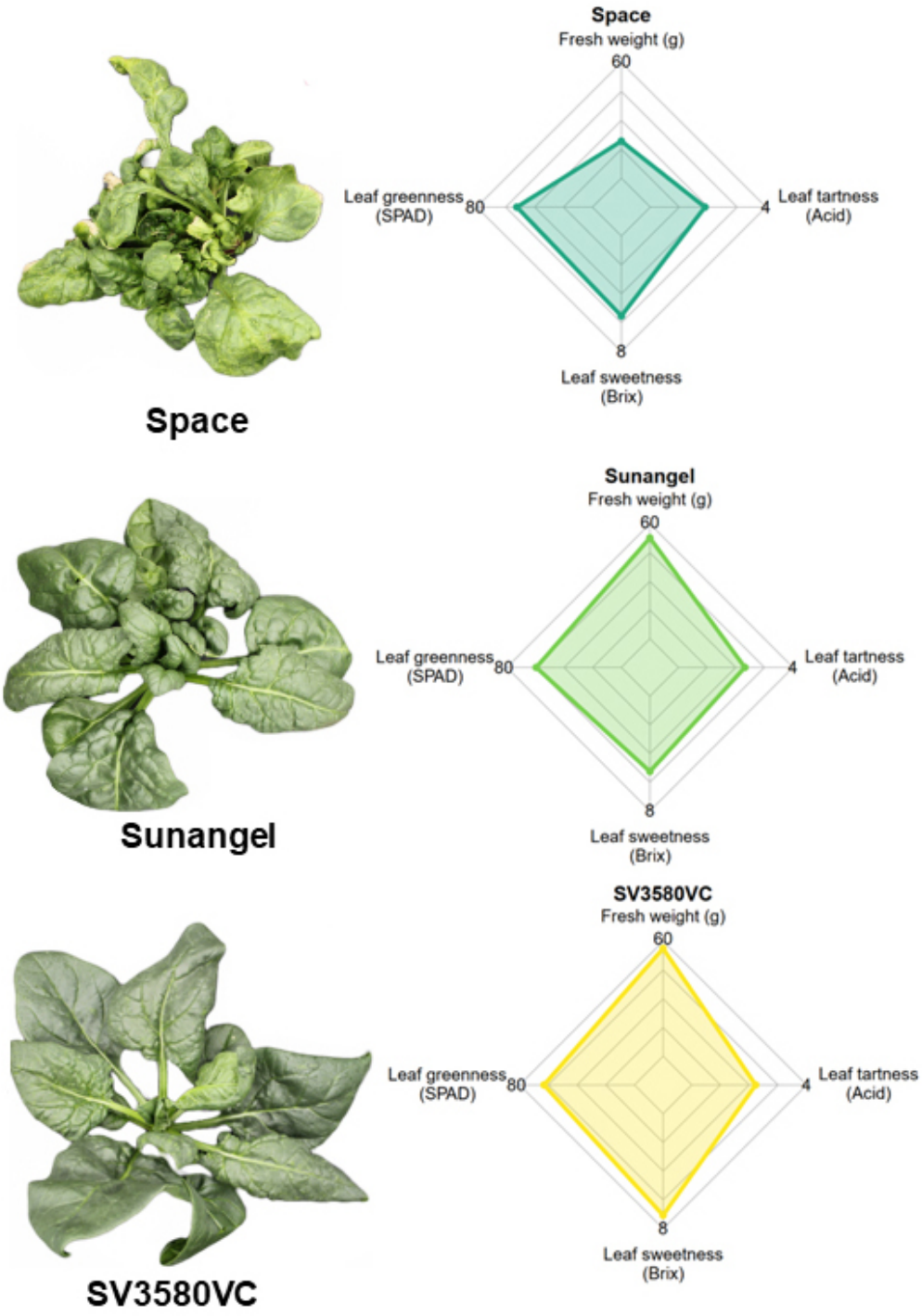


Figure 4. Potential Summer Spinach Cultivars for Georgia. These cultivars can be grown in a greenhouse during summer and offer benefits in yield (individual fresh weight), leaf greenness (SPAD), sweetness (Brix), and tartness (acid). Within the same parameter, different point values could be used for comparisons among cultivars.

It's essential for growers to match sweetness and tartness levels and balance to their consumers' taste preferences. To assist growers in making informed choices, here is a list of selected cultivars and their growth and taste profiles from the summer production trial. This allows growers to select cultivars aligned with their preferences.

- 'Kona' has a higher yield, and average greenness color, sweetness, and tartness.
- 'Lizard' has lower yield, sweetness, and tartness, and a higher leaf greenness.
- 'Seaside' has an average yield, and lower greenness, sweetness, and tartness.
- 'Space' has lower yield and tartness, and average greenness and sweetness, but is more susceptible to sunburn.
- 'Sunangel' has a higher yield, and average greenness, sweetness, and tartness.
- 'SV3580VC' has higher yield and sweetness, a lower tartness, and an average leaf greenness.

Use an Appropriate Hydroponic System

There are multiple hydroponics systems available on the market, and a deep water culture (DWC) system is a good choice for growing hydroponic spinach.

For our test, we used a small-scale DWC system to grow selected spinach cultivars during the summer in a greenhouse located in Griffin, GA. The system was composed of 50-gallon 4-ft wide by 4 ft long by 8-in. high trays covered with 4-ft by 4-ft by 1-in. high unfaced extruded polystyrene foam insulation boards drilled with 1 ¾-in. holes 6 in. apart (Figure 5).

Figure 5. A Deep Water Culture (DWC) Hydroponic System (left) Used for Greenhouse Spinach Production. An air pump (right) provided oxygen for roots in the system.

The DWC tray was filled with a solution made from 15-5-20 Jack's Nutrient fertilizer containing macro and micronutrients to provide a 150 ppm (mg/L) N concentration. To provide oxygen to the plant roots, each tray was aerated by two 2-in. air stones. The air stones were connected by a 5/16-in. (outside diameter; 3/16 in. inside diameter) clear extruded acrylic tubing to a 3,566 gph 6.96 psi aeration pump with a ½-in. outlet (see Figure 5, right image).

Typically, spinach seedlings needed 2–3 weeks after sowing before transplanting into the DWC system using a suitable net cup (e.g., 1 3/4 in. on top, 1 1/4 in. on bottom, and 1 7/8 in. deep). The crop was harvested after 3–4 weeks.

Summary

In conclusion, growing greenhouse spinach in the summer using deep water culture systems is feasible with several considerations. These considerations include choosing a cool site in a greenhouse with shade cover for seed germination, using the priming method to improve your seed germination rate, and selecting heat- and bolt-resistant spinach cultivars with high yield potential and superior taste.

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