



## Appropriate Spinach Cultivars for Spring Planting

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Spinach (*Spinacia oleracea*) is a popular leafy green vegetable often grown in the spring or fall months in the Midwest. Known for its nutritional characteristics, spinach is a high-value crop for growers. With an optimum growing temperature of 50°F to 60°F, spinach is known to bolt, or go to seed, in warmer weather. When this occurs, the leaf area is reduced and the spinach becomes unmarketable. Because of its sensitivity to heat, spinach often is more successfully grown in the fall under protection and harvested throughout the early winter months. Specific cultivars have been developed to tolerate higher temperatures of spring planting with delayed bolting, allowing growers to harvest spinach into early summer and increase the length of marketability and sales.

The objective of this study was to identify spinach cultivars best adapted to direct seeding for spring growth under Upper Midwest growing conditions.

### Materials and Methods

The study was conducted on certified organic land at the Iowa State University Horticulture Research Station. Twenty-one spinach cultivars, described for all seasons, summer growth, or heat tolerance, were selected. However, due to poor germination because of non-uniform moisture distribution, only nine cultivars could be evaluated. The nine cultivars evaluated include Acadia, Seaside, Kolibri, Red Tabby (Johnny's Selected Seeds), Renegade, Verdil (High Mowing Organic Seed Company), and Apache, Space, and Aztec (Seedway).

Plots were fertilized using compost from the Compost Facility, spread at a rate of 2.5 tons per acre on April 12. The compost was incorporated using a rototiller April 13 during termination of an overwintering cover crop of cereal rye. The study consisted of a total 12 plots, each measuring 25 ft. wide and 30 ft. long. Three plots consisted of one replication with a total of four replications. Each cultivar was grown in one row per replication. Cultivar row selection was randomized for a randomized complete block design.

The spinach cultivars were direct seeded April 22 with a Six-Row Pinpoint Seeder from Johnny's Selected Seeds. Bed width was determined by two passes with the seeder for a bed width of 24 in. Between row plant spacing was 2.5 in. and within row plant spacing was 2 in. with a total of 12 rows per bed. The crop was irrigated with drip irrigation and hand weeded as needed. The plants were monitored for pest and disease incidence in accordance with organic crop management guidelines. Caterpillar pests were managed using Dipel® Pro and PyGanic® 1.4 EC, sprayed using recommended rates on May 29.

Cultivars were visually evaluated June 1 for incidence of bolting, insect damage, and overall size. A rating of 0-5 was given for insect damage with 0 representing 0% of the plants in the bed displaying insect damage and 5 representing 100% of plants per bed affected; 1 represented 20%, 2 represented 40%, 3 represented 60%, and 4 represented 80% insect damage. Bolting was measured with the same 0-5 rating. Size was visually rated on a 1-5 scale based on largest leaf size and overall plant size; 5 represented the largest size and 1 represented the smallest.

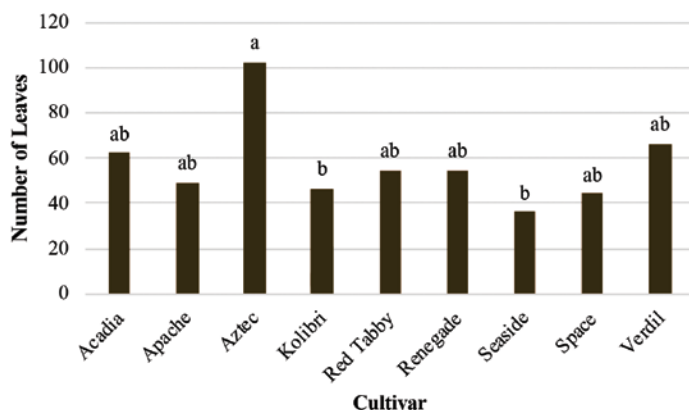
Spinach for yield data was harvested June 2 using a 30 cm by 30 cm quadrant placed in a randomly selected representative area of the bed. Spinach plants were cut at soil level and weeds were discarded. Harvested spinach then was categorized into marketable or non-marketable leaves (insect damage) and their number and weight were recorded. Non-marketable leaves were further categorized into insect damage, yellow discoloration, and small-sized. Small leaves measured less than 4 in. from petiole base to the tip of leaf apex, as per USDA size guidelines. The weight of leaves in each category was recorded.

Ten marketable leaves were selected and analyzed for chlorophyll content with a SPAD meter. The final SPAD value was an average of the 10 marketable leaves. These 10 marketable leaves also were analyzed for total soluble solid content. Liquid from the leaves was extracted by rolling them together and squeezing through a cheesecloth. The extracted juice was analyzed with a digital refractometer for total soluble solid (degrees Brix). Three readings were taken and averaged for the final Brix value per sample.

## Results

The average temperature for the growing period of this study was within the optimum range for spinach at 59.4°F. High temperatures generally exceeded 60°F through the growing period, with an average of 71°F, while low temperatures, with an average of 48°F, brought down the overall average to within the ideal range for spinach growth.

**Spinach marketable yield.** Kolibri and Seaside had significantly lower number of marketable leaves as compared with Aztec (Figure 1). Kolibri and Seaside marketable leaves per quadrant was 37 and 36 marketable leaves, respectively, compared with Aztec, which had 102 leaves. All other cultivars were statistically similar.



**Figure 1. Marketable number of spinach leaves per cultivar per quadrant at ISU Horticulture Research Station.**

## Discussion

Aztec, with the highest number and weight of marketable leaves per plot, performed the best among the nine cultivars. Seaside, with the lowest number and weight of marketable leaves, performed the worst. With the highest total soluble solid content, Aztec would be the most preferred in taste to consumers. Seaside, with the lowest total soluble solid content, would be the least preferred. Verdil, with the only incidence of bolting and the worst insect damage, appears to not perform well in spring planting. The shape and size of spinach leaves from Aztec and Seaside were quite different. Aztec has a large, pointy leaf while Seaside has a small, round leaf. This may be reflected in the significant weight of nonmarketable small leaves found for Seaside, as well as the high visual size rating for Aztec. Growers in Iowa considering spinach cultivars for spring planting should consider Aztec to be the best performer in terms of marketable yield and total soluble solid content. Seaside could pose challenges due to low yields and low total soluble solid content, and Verdil could pose challenges due to the incidence of bolting and susceptibility to insect damage.

There was no statistically significant difference among the cultivars for weight of marketable leaves (Table 1). Average marketable leaf weight was calculated by dividing the weight of marketable leaves per sample by the number of marketable leaves per sample. This provides an indication of the variability in leaf size of the different cultivars. Statistically significant differences were found between the cultivars (Table 1). Average leaf weight of Kolibri and Renegade, 2.5g and 2.3g per leaf, respectively, were higher when compared with other cultivars. Aztec had the lowest average leaf weight of 1.5g per leaf.

**Table 1. Spinach yield per plot at the ISU Horticulture Research Station from 2021 growing season.**

Cultivar	Marketable leaves (g)	Average leaf weight (g)	Insect damage (g)
Acadia	138.8	2.0 ab <sup>z</sup>	11.4 bc
Apache	84.6	1.7 bc	46.9 ab
Aztec	145.6	1.5 c	34.2 abc
Kolibri	117.1	2.5 a	14.4 bc
Red Tabby	90.3	1.7 bc	3.3 c
Renegade	124.5	2.3 a	40.6 abc
Seaside	71.2	2.1 ab	11.6 bc
Space	89.4	2.1 ab	60.7 a
Verdil	138.8	2.1 ab	72.3 a
P-value	0.8039	0.0109	0.0357

<sup>z</sup> Means within a column with the same letters are not statistically different (P < 0.05)

Insect damage to spinach leaves was significant by cultivar and by replication, indicating insect populations and damage were localized throughout the plots. Because all cultivars were present in all replications and randomized throughout the blocks, statistically significant differences between the cultivars still can be confirmed. Verdil and Space suffered the worst insect damage, with an average of 72.3g and 60.7g of leaves with insect damage, respectively. Red Tabby experienced the least insect damage, with an average of 3.3g of leaves with insect damage.

**Visual rating.** Aztec visual size rating of 3.9 was significantly higher than the rating for Kolibri, Space, Seaside, and Red Tabby (Table 2). Red Tabby and Seaside had the lowest visual size ratings, 1.3 and 1.9, respectively. Verdil and Apache received the highest ratings for insect damage, 1.44 and 1.38, respectively. These ratings were significantly higher than the insect damage rating for Red Tabby, Acadia, and Seaside. Verdil was the only cultivar that experienced bolting, with an average rating of 0.7.

**Leaf chlorophyll concentration.** Statistically significant differences in chlorophyll concentration, as measured by SPAD, of 10 marketable leaves was found among the cultivars (Table 3). Red Tabby had the highest SPAD value, although this variety is a red veined cultivar, which could have led to higher SPAD values. Among the other cultivars, Seaside had a significantly higher SPAD reading than Apache, Space, Renegade, and Verdil. Verdil had a significantly lower SPAD reading than other cultivars, which could be attributed to its naturally lighter green coloration.

**Total Soluble solid content.** Aztec had a significantly higher degrees brix than Seaside (Table 4). Apache brix was not statistically different from Aztec and was significantly higher than the sugar content of Seaside. No statistically significant differences were found among other cultivars.

## Acknowledgements

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**Table 2. Visual rating of spinach before harvest at ISU Horticulture Research Station.**

Cultivar	Size	Insect Damage	Bolting
Acadia	3.5 ab	0.2 d	0 b <sup>2</sup>
Apache	2.9 abc	1.4 a	0 b
Aztec	3.9 a	0.9 bc	0 b
Kolibri	2.7 bc	0.3 b	0 b
Red Tabby	1.3 d	0.2 d	0 b
Renegade	3.3 ab	0.5 bc	0 b
Seaside	1.9 dc	0.1 d	0 b
Space	2.5 bc	1.0 b	0 b
Verdil	3.3 ab	1.3 a	0.7 a

<sup>2</sup> Means within a column with the same letters are not statistically different (P < 0.05)

**Table 3. Average SPAD reading of 10 marketable leaves per spinach cultivar.**

Cultivar	SPAD
Acadia	40.0 bc <sup>2</sup>
Apache	39.8 c
Aztec	40.1 bc
Kolibri	40.5 bc
Red Tabby	47.3 a
Renegade	36.8 dc
Seaside	44.0 ab
Space	39.6 c
Verdil	34.9 d
P-value	0.0006

<sup>2</sup> Means within a column with the same letters are not statistically different (P < 0.05)

**Table 4. Average total soluble solid (°Bx) of spinach cultivars.**

Cultivar	Total soluble solutes (°Bx)
Acadia	4.87 bc <sup>2</sup>
Apache	6.23 ab
Aztec	7.50 a
Kolibri	4.47 bc
Red Tabby	5.20 bc
Renegade	5.07 bc
Seaside	4.55 c
Space	5.93 abc
Verdil	4.93 bc
P-value	0.0460

<sup>2</sup> Means within a column with the same letters are not statistically different (P < 0.05)