

Spinach Cultivar Trial in a 3-Season Haygrove High Tunnel

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Expanding spinach market

Annual spinach consumption increased in the US from an estimated 0.3 lb/capita in 1970 to 0.9 in 1998 (Heacox, 2000) and 2.5 lb/capita in 2003 (Boriss and Kreith, 2006). The increase is mostly due to consumption of fresh “baby” leaf spinach (Boriss and Kreith, 2003; Heacox, 2000). Fresh, clean, salad ready spinach brings premium revenues (Heacox, 2000). Growers using high tunnels are able to supply some of the market demand for spinach. A survey of growers in the central Great Plains found that leafy greens are a favorite crop for high tunnel vegetable production (Knewton, 2008).

Kansas growers are interested in recommended spinach cultivars for spring or autumn crops. Spinach production is mainly concentrated in the southwest US, California, Texas and Arkansas. Because of this seed cultivar selections are often based on production in those climatic zones. It was our intention to grow and record observations for spinach (*Spinacia oleracea* L.) cultivars planted in the autumn in northeast Kansas. Several seed companies provided seed that they either currently market, or are considering for market, in our region.

Materials and methods

Twenty-six spinach cultivars were planted in autumn 2005 in a 3-season Haygrove high tunnel and in adjacent field plots at the Kansas State University Horticulture Research and Extension Center, Olathe [latitude 38°53'N, elevation 1056 ft (322 m)]. The high

tunnel cover was removed for the winter on 10 December 2005 and replaced on 15 April 2006. From December through February the spinach was protected under a sheet of spun-bonded polypropylene fabric (Tyvar 580 floating row cover; Ken-Bar, Peabody, Mass.) held in place with sand bags. The spinach grew slowly during the cold winter with little freeze damage. Spinach was harvested twice, once in the autumn and once in the spring.

Six raised beds of 96 ft length and approximately 2 ft width were prepared in the north half of one bay of our 4-bay, half-acre Haygrove high tunnel. The distance between beds was 3 ft. Cultivars were randomized within pairs of beds, giving three replicates.

Irrigation was from overhead sprinklers. Raised seedbeds were prepared with a wheel hoe equipped with a furrower attachment. Bradfield Organic fertilizer 3-1-5 (Bradfield Industries, Springfield, Mo.) was applied to supply nitrogen at a rate of 136 lb/acre on 2 September 2005. Plots were about 5 x 2 ft, with about six inches of buffer zone between plots within rows. We seeded the beds with two passes of a 4-row pinpoint seeder giving eight rows of spinach per bed. The seeder can deliver a seed per inch of row.

Germination failure

Beds were seeded the first week of September. Germination was very poor. The field plots were a total failure. Under the high tunnel fewer than twenty plants survived in the majority of plots. Only the cultivars Hellcat and Highpack had 50-75 plants in one plot each. The weather was hot and this may have been a factor in the poor germination

that followed. We had used a roller to press the seeds into the bed. It is possible that some of the seed was pushed too deep. We determined that with the second planting we would sprinkler irrigate for short periods throughout the day to cool the soil and not use the roller.

Germination

Spinach was seeded a second time under the high tunnel on 27 September 2005. Germination was much improved, but not excellent in any plot. Based on observation, germination within a plot of less than 50 seedlings was rated as poor, 50 to 70 was fair, 70 to 100 was moderate, and 100 to 125 was rated as a good germination. Cultivar PVO172 had the best overall germination with an average of 104 plants per plot. Interceptor, PVO170, Space, Lombardia, Bloomsdale, Emilia, and Hellcat cultivars had moderate germination (Table 1).

Table 1. Germination and seed source of spinach seeded on 27 September.

Cultivar	Seed Source	Germination				
		three replicates			average ¹	average
		(plants per 10 ft ² plot)			(%)	(%)
Avenger	Seminis	62	62	62	62	13
Baker	Alf Christianson	35	62	62	53	11
Blackhawk	Seminis	62	62	62	62	13
Bloomsdale	Chesmore Seed Co.	62	87	62	70	15
C1-601	Alf Christianson	35	62	62	53	11
C1-608	Alf Christianson	62	62	62	62	13
C2-605	Alf Christianson	35	35	35	35	7
C2-606	Alf Christianson	62	62	62	62	13
C2-607	Alf Christianson	35	35	35	35	7
Emilia	Santa Clara Seed	62	87	62	70	15
Falcon	Seminis	35	62	62	53	11
Hellcat	Seminis	62	87	62	70	15
Highpack	Chesmore Seed Co.	35	62	62	53	11
Interceptor	Seminis	87	112	87	95	20

Lombardia	Santa Clara Seed	62	87	87	79	16
Melody	Chesmore Seed Co.	35	87	62	61	13
Olympia	Alf Christianson	62	62	62	62	13
PVO170	Santa Clara Seed	62	112	87	87	18
PVO172	Santa Clara Seed	87	112	112	104	22
Samish	Alf Christianson	35	62	62	53	11
Space	Johnny's Selected Seeds	87	87	87	87	18
Spinner	Johnny's Selected Seeds	35	62	62	53	11
Springer	Johnny's Selected Seeds	35	62	35	44	9
Tigercat	Seminis	62	62	62	62	13
Tyee	Chesmore Seed Co.	35	62	62	53	11
Umbria	Santa Clara Seed	62	62	62	62	13
LSD²					22	4.5

¹ Possible 480 seeds

² Least significant difference – values in the column above that differ by this amount are significantly different ($p = 0.05$).

Besides the effect on harvest yield, germination rate was also important because of the relationship to weed encroachment. Plots with poor spinach germination had more weeds later. Henbit (*Lamium amplexicaule* L.) was the main weed. Our only method of weed control was pulling by hand. Denser seeding would reduce weed pressure. This could be done by overlapping an increased number of passes with a wheel planter, using a closer spaced planter, or broadcasting seed. The cost in extra seed would likely be worth the reduced time spent pulling weeds.

Leaf texture and growth habit

We harvested the spinach as “baby spinach”. The ideal harvest size and shape is that of a soup spoon. All cultivars conformed to the spoon shape. Leaf texture is described as smooth or savoy (rippled). Some markets have a preference for smooth leaves. Growth habit and leaf texture are noted in Table 2.

Upright petiole growth allows easier harvest, especially if using a leafy greens harvester (consists of a serrated blade on a frame with a bag on the back of the frame to

hold the cut greens). Spinach with prostrate growth was harvested by holding bunches in the hand and cutting with a knife. Plots with upright growth were harvested with a leafy greens harvester from Johnny's Selected Seeds (Winslow, Maine). It is possible that some cultivars that seemed to have more prostrate growth habit could be forced to have upright petioles if more densely seeded.

Table 2. Leaf texture and growth habit of baby spinach planted 27 September 2005 under a high tunnel at Olathe, Kansas.

Spinach variety	Leaf surface texture	Growth habit
Avenger	smooth mostly, youngest leaves savoy	prostrate
Baker	mixed savoy and smooth	mixed
Blackhawk	smooth, mostly	mixed
Bloomsdale	savoy	upright
C1-601	savoy	mixed
C1-608	savoy	upright
C2-605	mixed savoy and smooth	upright
C2-606	smooth mostly	upright
C2-607	mixed savoy and smooth	upright
Emilia	mixed savoy and smooth	upright
Falcon	mixed savoy and smooth	mixed
Hellcat	mixed savoy and smooth	upright
Highpack	smooth, mostly	upright
Interceptor	smooth	upright
Lombardia	mixed savoy and smooth	upright
Melody	savoy	upright
Olympia	savoy, mostly	upright
PVO170	smooth	upright
PVO172	smooth, mostly	upright
Samish	savoy	prostrate
Space	smooth, mostly	upright
Spinner	savoy, few arrow shaped	upright
Springer	smooth mostly, youngest leaves savoy	mixed
Tigercat	smooth	upright
Tyee	savoy	upright
Umbria	smooth, mostly	upright

Harvest

Spinach was harvested in the autumn on 10 November 2005, and a second time on 11 March 2008. Average yield per 10 ft² plot is presented for each cultivar in Table 3.

The following cultivars were among the ten with highest yield in both harvests:

Interceptor, Highpack, Lombardia, Olympia, PVO170, and Tigercat. However, it should be noted that the cultivar with the highest combined yield, Interceptor, had a statistically significantly higher yield than only Spinner, Samish, C2-606, C2-605 and Tyee.

Table 3. Harvest yield of spinach planted on 27 September 2005 under a high tunnel at Olathe, Kansas. Yield is average of three replicated plots.

Variety	Harvest			
	10 Nov 2005	11 March 2006	Total yield	Total yield
	(lb per 10 ft ² plot)		(lb / plant)	
Avenger	1.35	7.06	8.42	0.14
Baker	1.40	6.45	7.85	0.15
Blackhawk	1.45	5.98	7.43	0.12
Bloomsdale	1.52	6.73	8.26	0.12
C1-601	1.47	5.93	7.40	0.14
C1-608	1.41	7.15	8.56	0.14
C2-605	1.05	5.12	6.17	0.18
C2-606	1.08	5.28	6.37	0.10
C2-607	0.86	6.87	7.73	0.22
Emilia	1.58	6.72	8.30	0.12
Falcon	2.20	6.48	8.68	0.16
Hellcat	1.52	6.02	7.54	0.11
Highpack	1.76	7.27	9.03	0.17
Interceptor	1.86	7.52	9.38	0.10
Lombardia	1.66	7.58	9.24	0.12
Melody	1.65	6.47	8.11	0.13
Olympia	1.62	7.13	8.75	0.14
PVO170	1.63	6.52	8.14	0.09
PVO172	1.94	5.86	7.81	0.08
Samish	1.21	5.50	6.71	0.13

Space	1.96	5.82	7.78	0.09
Spinner	1.68	5.05	6.73	0.13
Springer	1.30	6.34	7.64	0.17
Tigercat	1.65	7.96	9.61	0.16
Tyee	1.37	4.42	5.79	0.11
Umbria	1.37	6.11	7.49	0.12
LSD ¹	0.72	2.19	2.39	0.073

¹ Least Significant Difference – values in the column above that differ by this amount are significantly different ($p = 0.05$).

The second harvest was of greater mass, but the leaf size not much larger than the first harvest. The plantlets seemed to have put on more leaves.

Spring bolting

After the second harvest, on 11 March, the weed population took over. We were not able to devote the time it would have required to hand pull all of the spring weeds. We continued to water the spinach and let it grow long enough to observe how the cultivars responded to warm weather.

On 2 May 2006, observations of spinach bolting were recorded (Table 4). The least objectionable warm weather effect was petiole lengthening. This might make harvest easier and did not detract from the leaf form. At the time of evaluation, some cultivars had developed elongated internodes that are typical of bolting, but had not yet flowered. Some cultivars had developed flowers or gone to seed. Leaves on the cultivar Springer elongated and became arrow shaped. Spinach cultivars that had the best appearance and least bolting effects in warm weather were: Blackhawk, C1-601, C2-606, Interceptor, PVO170, PVO172, Space and Umbria.

Table 4. Spring bolting of spinach as observed on 2 May 2006. Spinach was planted on 27 September 2005 and over wintered in a high tunnel. (n = no bolting effects, e = elongated internodes, p = petioles long, f = flowers, s = seed formation)

Variety	Bolting		
	replicate 1	replicate 2	replicate 3
Avenger	e	pe	e
Baker	efs	efs	efs
Blackhawk	p	p	n
Bloomsdale	e	ef	ef
C1-601	p	p	p
C1-608	efs	efs	ef
C2-605	e	e	n
C2-606	p	p	n
C2-607	efs	ef	pe
Emilia	e	pe	n
Falcon	ef	ef	ef
Hellcat	e	e	e
Highpack	efs	efs	efs
Interceptor	n	e	p
Lombardia	n	pe	e
Melody	p	e	e
Olympia	n	pe	e
PVO170	n	p	n
PVO172	p	p	n
Samish	efs	efs	efs
Space	n	pe	p
Spinner	n	e	e
Springer	arrow shape	e	arrow shape
Tigercat	e	n	e
Tyee	pe	e	p
Umbria	p	p	n

Research Continuation

Information presented in this report such as germination, leaf appearance and spring bolting may be of current interest for growers in our climatic zone [Plant hardiness zone 5 (USDA, 1990)]. Harvest yield data will be of more value when added to

additional years of cultivar trials. Cultivar trial data are more reliable when results are collected over a few years. Performance of autumn planted spinach may vary from year to year depending on weather (cloud cover, temperature, and early and late frost).

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