ECOLOGICAL FARMERS ASSOCIATION OF ONTARIO

SEED PRODUCTION & BREEDING

FARMER-RESEARCHERS

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Root Cellar Gardens and Roots to Harvest are both located on the traditional lands of the Fort Williams First Nation signatory to the Robinson-Superior Treaty of 1850, and the traditional territory of the Anishinaabeg and Métis peoples.

RESEARCH REPORT 2021

Spinach variety trial for northwestern Ontario seed production

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IN A NUTSHELL

Growers in northwestern Ontario wanted to identify which varieties of spinach are well-suited for seed production in their area.

- Matador and Popeye were among the growers' favourite varieties, ranking high in most categories.
- Giant Winter was the growers' least favorite variety and was ranked lowest in almost every category.
- Spinach planted in later fall (frost seeded) did not survive to produce seed in this trial.
- From unreplicated data, early fall plantings overwintered successfully and show a trend towards higher seed production.

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MOTIVATION

Spinach is a crop with highly geographically specific seed production. This day-length sensitive species requires long days in order to flower, so it is best grown for seed in northern latitudes (**1**). Spinach plants respond to increasing day length by bolting: sending up a flowering stalk and setting seed. At the time of year when spinach seeds are ripening, optimal temperature, humidity, and air flow are key to harvesting spinach seeds at their peak. Most of the world's spinach seed production occurs in Washington State (49° N) and Oregon (44° N) in the USA and in Denmark (56° N) (**2**). The Thunder Bay region (48° N) is thus a viable location for spinach seed production due to its long summer days.

Several Ontario seed companies have expressed concerns around spinach seed supply. There is currently a conspicuous lack of Canadian grown spinach seed available. The global pandemic in 2020 saw a huge increase in demand for seed worldwide, and then August brought intense wildfires to the main seed growing regions of the US. These realities heightened seed insecurity for the growers, and they decided to see if they could do some learning to help in their own way.

The purpose of the trial is to identify which varieties of spinach are well-suited for seed production in northwestern Ontario. This project will assess whether there is a difference among varieties when it comes to viable, vigorous seed production, and which planting dates produce the best spinach seeds.

METHODS

Growers evaluated 6 varieties of open-pollinated spinach (**Table 1**). They planted each variety at four planting dates (spring, summer, frost seeded, and spring) to see if the timing of seeding affects the time when spinach plants go to seed and, in turn, yield. Due to planting delays summer plantings were moved to the fall. This was done at two replicate sites in northwestern Ontario: Root Cellar Gardens in South Gilles and Roots to Harvest's Lillie Street Seed Garden in Thunder Bay. A third site was planned for the Lakehead University Community Garden but due to unforeseen issues surrounding site space, the site was not used. At each site, growers amended soil as necessary.

Photo 1. Planting Summer Spinach Seed Trial at Root Cellar Gardens.

Table 1. Complete list of the open-pollinated spinach varieties that growers selected to trial.

VARIETY	DTM	LEAF-TYPE	SEASON	SOURCE	NOTES
Longstanding Bloomsdale	45	Savoyed	Spring/fall	High Mowing	Cold hardy
Abundant Bloomsdale	45	Savoyed	Spring/fall	High Mowing	High yield
Giant Winter	50	Savoyed	Fall/overwinter	High Mowing	Cold hardy
Butterflay	40	Semi-savoyed	Spring/fall	High Mowing	Productive
Matador	43	Flat	Fall/overwinter	High Mowing	Cold hardy
Popeye	40-50	Savoyed	Spring/fall	Root Cellar Gardens	Late bolting

Growers evaluated each spinach replicate in the same way for all planting dates. Growers measured germination rate and yield (of harvested seed), and ranked all other traits seen in **Table 2**. They ranked the 6 varieties against each other on a scale from 1 - 6, one being the best, and six being the worst for each trait. Anything noteworthy was recorded in their notes (**Table 3**).

Planting and seed setting information can be found in **Table 4**. When plants were mature and dried down, growers harvested seeds from each variety. After varieties were harvested, seed lots were tested for yield, germination rate and vigour of seedlings. Weighing and germination testing of harvested seed lots was done by Root Cellar Gardens.

DATA ANALYSIS

Both replicates of frost-seeded spinach and one fall-seeded spinach did not survive after planting. As such, we removed replicates 2, 3, and 6 from data analysis.

To evaluate the effect of variety on seed yield and seed germination, we used a statistical model called analysis of variance (ANOVA) with a 90% confidence level to calculate the least significant difference (LSD) needed to call the treatments "statistically different".

Using a 90% confidence level means that if we measure a difference between any two treatments that is greater than the calculated LSD, we expect this difference would occur 9 times out of 10 under the same conditions. In this case, we consider the difference reliable and refer to the results as statistically significant. On the other hand, if we measure a difference between any two treatments that is less than the calculated LSD, we consider these treatments unreliably different or statistically similar. We could make these statistical calculations because the growers' experimental designs involved replication of the farm sites over time.

To evaluate the effect of variety on the ranked data of germination at planting, vigour, grower preference, disease resistance, bolting resistance, lodging resistance, and seed vigour we used a statistical model called the Kruskal-Wallis Test with a 90% confidence level to calculate a significant difference to call the treatments "statistically different".

FINDINGS

Germination at Planting, Vigour, and Grower Preference

Growers found no significant difference in the rank of germination at planting (P=0.14), plant vigour (P=0.45), or grower preference (P=0.91) among any of the varieties tested (**Table 5**). Abundant Bloomsdale and Popeye ranked highest for germination and Giant Winter ranked lowest. For plant vigour, Giant Winter ranked the lowest; Matador and Popeye ranked highest. Matador ranked highest for grower preference and Giant winter again ranked the lowest.

Photo 2. Spinach at leaf stage, 2020.

Photo 3. Ovary and pollen bearing spinach plants showing dioecious reproduction system of spinach.

Table 2. Ranked traits, stage of observation, information to consider when ranking, and what growers will do for each planting date.

TRAIT	STAGE OBSERVED	INFORMATION CONSIDERED WHEN RANKING	WHAT GROWERS WILL DO:
Germination rate	Emergence	# Seeds sown/ # seeds germinated	
Vigour of seedings	Emergence/seedling stage	Robustness of seedlings/ # plants needing to be rogued	Rogue out weak seedlings
Disease	Full leaf/leaf maturity	How many plants have observable disease?	Rogue out diseased plants
Overall Quality	Full leaf/leaf maturity	Do you like it? (production, uniformity, taste, etc). Is it worth growing?	
Bolt Resistance	Bolting	Number of plants rogued out due to bolting	Rogue out any early bolting plants
Lodging Resistance	Seed production	Number of Plants that lodged	
Seed yield *	Harvest	Total grams/ per bed foot?	
Seed germ rate *	Germination	Seeds sown/seeds germinated	
Vigour of in germination tests	Emergence/seedling stage		

**These traits were not ranked data, seed yield was in total grams and seed germination was in percent.*

Table 3. Grower notes for each variety in the trial.

VARIETY	ROOT CELLAR GARDEN	ROOTS TO HARVEST*
Longstanding Bloomsdale	Taste and picking favourite along with Popeye. More susceptible to logging,	Bitter, juicy, bitter, not bitter
Abundant Bloomsdale	Last to bolt in both plantings that survived. Last to mature seed as well.	Robust, solid, strong, bitter ending
Giant Winter	Least favourite in terms of taste and picking, bolted quickly – by far the shortest picking window	Fuzzy, bitter, bittersweet, little savoury, velvety, chewy
Butterflay	-	Thin leaf, sweet, not bitter, no mineral taste, pleasant, light, not juicy
Matador	-	Full, soft, not chewy, watery, nice after flavour, swiss chard taste
Popeye	Taste and picking favourite along with Longstanding Bloomsdale	Thick leaves, high water content, nutty, minerally, liked

** Tasting notes in this chart are from multiple growers and vary based on palette.*

Table 4. Planting date and seed set information for both growers.

DATE SOWN	DATE HARVESTED	LOCATION	REPLICATE	GREW TO PRODUCE SEED?
Spring: May 6, 2020	-	Roots to Harvest	4	Yes
Spring: May 10, 2020	July 25	Root Cellar Gardens	1	Yes
Fall: September 8, 2020	-	Root Cellar Gardens	2	No
Fall: October 6, 2020	August 13	Roots to Harvest	5	Yes
Frost Seeded: October 20, 2020	-	Root Cellar Gardens	3	No
Frost Seeded: November 3, 2020	-	Roots to Harvest	6	No
Spring: May 6, 2021	July 31	Root Cellar Gardens	7	Yes
Spring: May 13, 2021; re-planted June 11, 2021	August 25	Roots to Harvest	8	Yes

Disease, Bolt, and Lodging Resistance

Table 6 shows, there was no significant difference in rank among varieties for disease resistance (P=0.99), bolt resistance (P=0.58), or lodging resistance (P=0.42). Giant Winter ranked highest among varieties for disease resistance while Abundant Bloomsdale ranked lowest. Growers ranked Longstanding Bloomsdale and Butterflay most resistant to bolt, while they ranked Giant Winter most prone to bolting. They ranked Matador highest for lodging resistance, and Giant Winter and Longstanding Bloomsdale most likely to lodge.

Seed Yield, Germination, and Vigour

The mean seed yield and seed germination rate for each variety can be seen in **Table 7**. Growers found no significant difference in seed yields among the varieties tested (P=0.96). Using an LSD, growers would have needed to see a difference of 196 g among the varieties tested to have seen a significant difference.

Table 5. Mean rank data for germination at planting, plant vigour, and grower preference across farms and replications for the six tested varieties.

VARIETY	GERMINATION AT PLANTING	PLANT VIGOUR	GROWER PREFERENCE
Longstanding Bloomsdale	3	3	3
Abundant Bloomsdale	2	3	3
Giant Winter	5	5	4
Butterflay	3	4	3
Matador	3	2	2
Popeye	2	2	3
Kruskal-Wallis	NS*	NS*	NS*

** = Not significant*

Table 6. Mean rank data for disease, bolt, and lodging resistance across farms and replications for the six tested varieties.

VARIETY	DISEASE RESISTANCE	BOLT RESISTANCE	LODGING RESISTANCE
Longstanding Bloomsdale	3	2	4
Abundant Bloomsdale	4	3	3
Giant Winter	1	5	4
Butterflay	2	2	3
Matador	2	4	2
Popeye	3	3	3
Kruskal-Wallis	NS*	NS*	NS*

** = Not significant*

There was a significant difference between growers (P=0.06) in which on average in the spring plantings Root Cellar Gardens produced more seed than Roots to Harvest. With one fall planting replicate, gowers noticed a trend that seed yields were more than doubled that of the spring plantings (**Figure 1**).

The growers also found no significant difference in seed germination among the varieties tested (P=0.93). Using an LSD, they would have needed to see a difference of 21% among the varieties tested to have seen a significant difference. There was a significant difference between growers (P=0.06) in which on average in the spring plantings, Root Cellar Gardens' germination was higher than Roots to Harvests'. With the one fall planting replicate, gowers noticed that germination was higher than that of the spring plantings (**Figure 2**).

Growers think that overwintered fall planted spinach would make better seed than spring planted because the plants would be larger when they begin to bolt. Roots to Harvest noticed this in their fall planted spinach vs the summer planted spinach. Growers also think that because Thunder Bay is closer to Lake Superior it doesn't get the same extreme temperatures as South Gillies. It is very likely that cold weather in fall or spring, when there was no snow, killed the fall planted replicate at Root Cellar Gardens but not at Roots to Harvest.

There was no significant difference in the rank of seed germination vigour among any of the varieties grown (P=0.72). The growers ranked Longstanding Bloomsdale highest, followed by Popeye, and than Abundant Bloomsdale, Giant Winter, Butterfly, and Matador (**Table 7**).

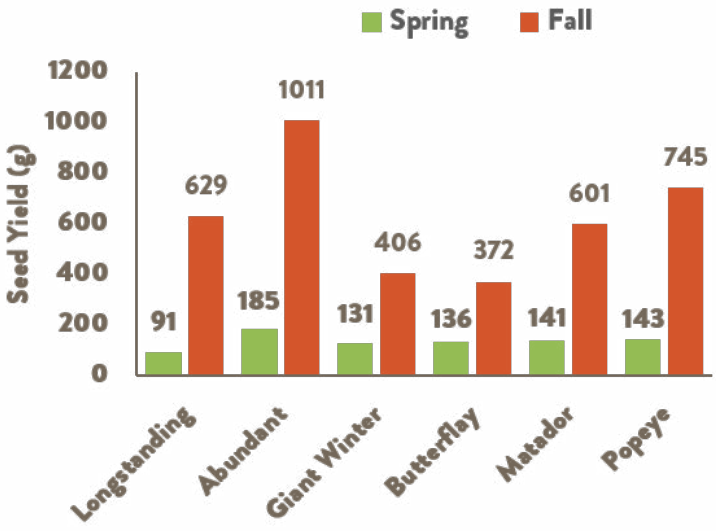

Figure 1. Mean seed yield in grams for 6 varieties in the spring (4 replicates) and fall (1 replicate) plantings.

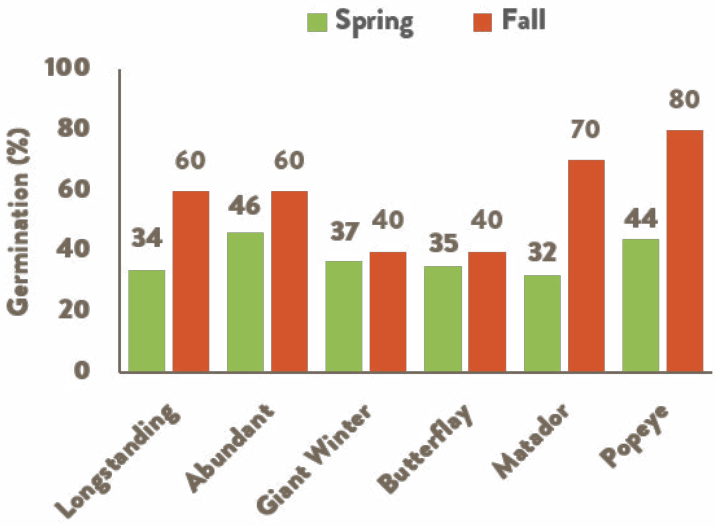

Figure 2. Mean percent germination for 6 varieties in the spring (4 replicates) and fall (1 replicate) plantings.

Photo 4. Spinach Seed Harvest with Roots to Harvest crew at the Lillie Street Garden.

CAVEATS

Replication four at Roots to Harvest produced a lot of seeds but due to lack of drying space some varieties were mixed. Because of this, growers could not take seed weights for Longstanding Bloomsdale, Giant Winter, or Butterflay for this replication.

Overall, as a consequence of space and staffing issues, growers lost replications and, in turn, some statistical power. To detect a potential effect in the rank data, growers would need to replicate the study again.

NEXT STEPS

Growers are curious continue to assess whether frost seeding and fall planting are reliable ways to grow plants that are more mature when they bolt.

Growers will use the Popeye variety to continue this work. Growers at Root Cellar Garden would like to continue to collaborate and learn with growers at Roots to Harvest.

Photo 5. Cleaned Spinach Seed, 2021.

Table 7. Mean seed yield, germination, and vigour across farms and replications for the six tested varieties.

VARIETY	SEED YIELD (G)	SEED GERMINATION (%)	SEED VIGOUR (RANK)
Longstanding Bloomsdale	91	34	2
Abundant Bloomsdale	185	46	4
Giant Winter	131	37	4
Butterflay	136	35	4
Matador	141	32	4
Popeye	143	44	3
LSD	NS*	NS*	NS**

** = Not Significant ** = A Kruskal-Wallis test was run for this rank data.*

TAKE HOME MESSAGE

In this trial, growers found that frost seeding was not an optimal planting time for northwestern Ontario as seedlings germinated but did not survive over the winter. With only one replication, the fall planting showed trends towards higher seed production and might prove to be an ideal planting time for seed producers in northwestern Ontario.

Popeye and Matador ranked highest and were among the growers' favourite varieties planted. Giant Winter ranked poorly in almost every category and was the growers' least favourite variety.

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