



**MANITOBA
CROP ALLIANCE**

DEVELOPMENT OF LONG-TYPE CONFECTION SUNFLOWER HYBRIDS

***YEAR 4: 2021-2022
Performance Report***

March 31, 2022

ACTIVITY 1: SUMMER AND WINTER NURSERY

The objective of the summer and winter breeding nurseries is to develop elite parent lines, possessing genes for tolerance to sulfonylurea herbicides, rust and downy mildew that will, when crossed, produce herbicide tolerant experimental hybrids highly adapted to Canada, with a prominent level of resistance to downy mildew and rust, and possess improved seed types for Canadian processors and producers. For simplicity, the breeding of male and female parent lines in our program generally follows the same process.

The 2021 summer nursery was planted near Fargo, North Dakota with a total of 2,080 rows.

The goals for the 2021 nursery included:

- Generation of new breeding populations (male restorer and female AxB lines) with desired characteristics from crossed plants
- Selection in segregating populations for yield, seed type, agronomic integrity, and presence of genes for herbicide tolerance and disease resistance
- Select early and late generation populations at contra season nursery
- Identification of new homozygous parent lines resistant to rust and downy mildew for use in production of preliminary hybrids.
- Identification of genetic material with the herbicide tolerance gene
- Advancement of male restorer lines and female parent lines to semi-elite or elite category
- Interim report on agronomic ratings and disease resistance.

Activity 1 met its Year 4 (2021-22) objectives to develop elite parent lines, possessing genes for tolerance to sulfonylurea herbicide (SU-7: non-transgenic), rust (R_{12}) and downy mildew (PL_{ARG}) to provide a competitive production advantage to existing hybrids. The following quantities of finished, and unfinished parent lines were grown. The quantities of lines contained in the program are as follows:

- Finished male restorer lines - no dominant disease resistance genes. Elite (19)
- Finished male restorer lines - no dominant disease resistance genes. Semi- Elite (11)
- Finished male restorer lines fixed for gene PL_{ARG} or PL_{ARG} and R_{12} Elite (35)
- Finished male restorer lines fixed for gene PL_{ARG} or fixed for both PL_{ARG} and R_{12} . Semi-Elite (51)
- Finished female A x B lines with cytoplasmic male sterile conversion completed. Elite (23)
- Finished female A x B lines with cytoplasmic male sterile conversion completed. Semi-Elite (47)
- Based on the 2020 and 2021 SNP marker data, there currently are approximately 177 males lines (finished + unfinished) in the program fixed for the downy mildew resistance (PL_{ARG}).
- Based on the 2020 and 2021 SNP marker data, 153 male lines (finished + unfinished) in the program fixed for both downy mildew resistance (PL_{ARG}) and the rust resistance (R_{12}).
- A new female development program that includes PL_{ARG} and R_{12} was initiated in the 2017-18 winter nursery. Based on the 2021 SNP marker data, 4 of the new A x B lines containing PL_{ARG} and R_{12} , a were advanced for use in experimental hybrids. These female lines all possess a highly desirable seed type, phenotype, and are agronomically solid. All four of the lines will be used in hybrid combinations for testing in 2022.



Generation of new breeding populations (male restorer and female AxB lines) with desired characteristics from crossed plants

Development of Male Restorer Lines:

SUMMER 2021

- Plants were selected from F₂ populations. Selected F₂ plants were rated for agronomics and seed type.
- Tissue samples were taken from the top rated F₂ plants and marker screened for dominant disease resistance genes.
- F₄ plants were selected. Selected F₄ plants were rated for agronomics and seed type.
- Tissue samples were taken from the top rated F₄ plants and marker screened for dominant disease resistance genes.

WINTER 2021-22

- F₃ plants were selected in the winter nursery (Chile) based primarily on earliness and plant type.
- F₅ plants were selected in the winter nursery based primarily on earliness and plant type.



Figure 1. Chile winter nursery.

Development of Female AxB Lines:

SUMMER 2021

- F₂ plants were selected before bloom based on earliness and plant type and a first cross was made to cytoplasmic male sterility.
- The top rated F₂ plants (AxB pairs) were advanced to winter nursery based on agronomics and seed type.
- F₄ plants (AxB pair) were selected based on earliness and plant type with a third backcross made to cytoplasmic male sterility.
- The top rated F₄ plants (AxB pairs) were advanced to the winter nursery based on agronomics and seed type.

WINTER 2021-22

- F₃ plants (AxB pairs) were selected based on earliness and plant type and a second backcross was made to cytoplasmic male sterility.



- F₅ plants (AxB pairs) were selected based on earliness and plant type with a fourth backcross made to cytoplasmic male sterility. If female conversion to sterility was complete, the new female A x B line was used to make experimental hybrids for testing in the 2021 summer nursery.

RESULTS

- Selection in segregating populations for yield, seed type, agronomic integrity, and presence of genes for herbicide tolerance and disease resistance
- Identified new homozygous parent lines for production of preliminary hybrids.
- Screened new parental line material for resistance to rust (R₁₂ gene), downy mildew (P_{LARG}).
- Screened material for the herbicide tolerance gene SU-7.
- Collected agronomic ratings on maturity, lodging, height, disease, and a general visual screening of materials.

Herbicide Tolerance Screening

All parent lines in the program were developed with herbicide tolerance. The SU-7 gene is a single dominant gene from DuPont that conveys herbicide tolerance to tribenuron in sunflower. The trait has been incorporated into 100% of the program parental lines and early generation material, after successful completion of the five-year funding under GF2 “Confection Sunflower Development Initiative”.

Both the summer and winter nurseries are sprayed with a two times rate of tribenuron to confirm that the presence of the trait within the hybrids. Any hybrids that show injury are discarded.

MCA collected tissue samples in the summer of 2020 to confirm the prevalent races found in Manitoba.

Downy Mildew, Rust, and Sclerotinia Screening

Breeding activities in the male and female parent line program include the incorporation of genes for disease resistance (downy mildew: P_{LARG}, rust: R₁₂).

Male and female parent lines that contain the resistant genes were screened to confirm that the resistance genes were present. Plants that contain the resistance genes were selected for further advancement into the 2021-22 winter nursery

Fifty-two new herbicide tolerant male restorer lines (F₅) that are fixed for downy mildew resistance were identified. Twenty-three of these lines were used in the winter breeding nursery to make experimental hybrids for testing in 2021 and were advanced to activity two.



Based on agronomics, seed type and SNP marker information obtained from individual plants, four new F₅ female lines were identified that contain genes for downy mildew and/or rust resistance and were advanced to the 2021-22 winter nursery. Conversion to cytoplasmic male sterility (CMS) of the four new female lines was initiated in the 2018-19 winter nursery. CMS conversions was completed in the 2020 summer nursery. The four new female lines containing genes for resistance were advanced to the 2021-22 winter nursery and were used to make experimental hybrids for testing in Manitoba in 2022.

Currently in the program, there are approximately 202 finished parent lines that have been utilized to make experimental hybrids used for testing in Canada (136 males, sixty-six females) since the program started testing herbicide tolerant hybrids in 2014. All 202 lines are herbicide



Figure 2. Fargo, ND nursery July 14, 2021.

tolerant and have been advanced through the program based on solid agronomics, seed type and adaptability to Canadian growing conditions. Ninety-four of the male lines contain genes for resistance to downy mildew, or downy mildew and rust.

Based on comparative yields and seed types obtained from experimental hybrids evaluated in Manitoba in 2021, the program currently has the potential to produce a high number of experimental hybrids that can yield competitively and can produce improved seed types to commercial confection hybrids currently being grown in Canada. High yield performance and improved seed types in combination with herbicide tolerance and genetic disease resistance will provide attractive hybrid options for Canadian producers.



ACTIVITY 2: CANADIAN TESTING PROGRAM

The overall objective of the Canadian Testing Program is to isolate commercially viable experimental hybrids for advanced testing and eventual commercialization. While seed type and marketability are of extreme importance, the hybrids must also be early maturing, high yielding and have a strong agronomic package. Testing activities will include four levels of testing.

Preliminary Hybrid Screening

Planting Date: May 31 (Elm Creek) and May 31 (Holland)

The MCA transports our planting equipment from Fargo, ND to plant the two preliminary screening nurseries. This process has eliminated planting errors and ensures that the trials are planted at the desired time.

132 preliminary hybrids were selected from the 2019-2020 Summer and Winter nurseries to be evaluated at two locations in Manitoba. Each location had two rows and was replicated twice. The trials included two commercial performance checks (6946 DMR & Panther DMR) and one SU-7 herbicide check (P63ME70). The two commercial performance checks are not tolerant to the SU-7 herbicide, so they were strategically placed along the edges of the trials. They were sprayed with conventional herbicides and hand-weeded if needed.



Figure 3. Holland, MB nursery July 14, 2021

The two Manitoba nursery locations also included an “Advanced Yield Trial” (AYT) that had elite hybrids selected from the Preliminary trials in 2020. Twelve elite hybrids were selected for a second year of testing alongside the preliminary nursery. The AYT had two row plots that were replicated three times. Data collected from both the preliminary screening nurseries and the AYT included standard agronomic traits for: emergence, herbicide tolerance, days to bloom, days to maturity, plant lodging, seed yield, seed test weight, seed sizing and percentage of nut-meat ratio.

The trial was sprayed and tilled by a contract services company in both locations and plot maintenance



including thinning was performed by MCA's Research Trial Specialist. Benchmarks for a commercial confectionary hybrid were:

- Herbicide tolerance: resistance to sulfonylurea herbicide: SU-7;
- Seed Type: Dark color, long (1.9-3.2 cm) seed with shoulder width;
- Disease resistance: resistance to Downy Mildew (PL_{arg}) and Rust (R₁₂);
- Early maturity: less than or equal to the commercially available hybrid check or about 117 days to R9 maturity;
- Improved yield over commercially available hybrids;
- General plant integrity/agronomics – acceptable height, good lodging tolerance, and good overall agronomic package.

MCA's Research Trial Specialist and contract breeder hand clipped and threshed the sunflower heads from the selected lines on October 6th (Holland). The harvested sunflower seed was dried before samples could be weighed. The seed from the plots was cleaned, weighted for yield and bushel weights on October 14th.

Of the 132 new preliminary lines evaluated in 2021, 33 were taken to harvest and evaluated for yield, agronomic and seed quality traits. Based on the overall performance along with seed appearance and quality, eighteen hybrids have been selected for the next level of testing in 2022. Seed of the selected eighteen hybrids is being produced in the 2021-2022 winter nursery in Chile for trialing in Manitoba in 2022.

Variety Performance Trials

To evaluate the elite hybrids against other commercially available sunflower hybrids for their agronomic competitiveness, merit, and regional adaptation. Each Variety Performance Trial consisted of three replications using a RCBD (Randomized Complete Block Design) for data analysis.

One elite hybrid was evaluated in the VPTs that were located at 4 locations in Manitoba in 2020. These locations were: Melita, Carberry, Rossendale, and Elm Creek. All four locations were planted and taken to harvest. The Carberry site was lost due to the trial having a high CV (Coefficient of Variation) for seed yield. The trial at the Elm Creek location was reseeded due to herbicide drift by the landowner from the surrounding field. The complete set of trial results were published on the MCA website at <https://mbcropalliance.ca/resources/sunflowers> in November 2021 and in Seed Manitoba.



Figure 4. Rossendale, MB VPT trial Aug 2021



Table 1: 2021 Variety Performance Trial Results

SUNFLOWERS - CONFECTIONARY TYPE									
Comments:									
These varieties were tested and data donated by the Manitoba Crop Alliance (MCA).									
All sunflowers varieties listed are susceptible to sclerotinia and sunflower rust strains present in Manitoba.									
Genetic resistance to verticillium wilt is rated as moderately susceptible to moderately resistant for all sunflower varieties presented.									
Plant population and environment will contribute greatly to the final product.									
Variety Descriptions									
Company	Hybrid	Genetic Traits ¹	Site Years	Yield % Check	Maturity ² (+/- check)	Height (inches)	Seed Sizing (%) ³		
							>22/64	>20/64	<20/64
NuSeed	6946 DMR	DM	31	100	0	0	35	30	33
NuSeed	Panther DMR	DM	39	100	0	-2	53	26	17
Experimental lines tested/proposed for registration in Canada									
CHS Sunflower	20-EXP3	ExSun	3	90	6	-1	51	24	25
CHS Sunflower	21-EXP1	ExSun	3	94	6	4	26	35	38
MCA	EX 35957	ExSun	6	110	-3	2	53	21	26
NuSeed	N6L377 CL	CL	3	97	1	-1	47	25	29
CHECK CHARACTERISTICS									
6946 DMR			31	3022	121	65			
			site years	lb/ac	days	inches			
1 Genetic traits include CL = Clearfield tolerance; ExSun = Express tolerance; DM = Downy Mildew Resistance.									
2 Physiological maturity for sunflowers is R9, where the bracts on the head are almost completely brown.									
3 Totals may not add to 100% due to rounding; information based off three sites at Elm Creek, Melita, and Rossendale.									
Refer to the MCA website at www.mbcropalliance.ca for more details.									

Commercial Strip Trial Testing

Advanced successful experimental hybrid(s) to the next level of testing, pre-commercial strip trial testing.

One elite hybrid (EX 35957) from the 2020 Preliminary Nursery was advanced and evaluated at three locations within Manitoba in a head-to-head, field scale comparison with the commercial hybrid, 6946 DMR. The field strips were a minimum of eight rows wide by at least 1000' long. The elite hybrid in the strip trials was treated the same as the commercial hybrid in the producer's field using their commercial scale equipment and their usual farming production practices. The trial was managed by the producer throughout the entire growing season. During the season, agronomic data was collected on the field strips. Both the elite hybrid and the commercial hybrid were harvested with a weigh wagon capturing the seed yield. Seed samples were collected for further seed quality analysis (visual appearance, test weight, seed sizing, % nut meat).

Both the trials at Wawanesa and Westbourne were planted on 30" row spacings, while the trial at Rossendale was planted on 22" row spacings. The trial at the Wawanesa site had a good spring shower resulting in excellent emergence, while the trial at the Westbourne location received little rain through the entire growing season. There was little rain at the Wawanesa site for the rest of the growing season. The Rossendale location received timely rains but was still dry as compared to an average year. Due to



the dry growing season at the Westbourne location the sunflower plant height remained shorter than normal. There were weed issues at the Rossendale site that resulted in that location requiring inter-row cultivation.

All the trials/locations were harvested with seed samples being collected. Seed quality was performed on the retained samples. The results from the pre-commercial strip trials are summarized in Table 2.

Table 2: 2021 Sunflower Pre-Commercial Strip Trial Results

2021	Wawanesa, MB - 2021		Rossendale, MB - 2021		Westbourne, MB - 2021	
	EX 35957	6946 DMR	EX 35957	6946 DMR	EX 35957	6946 DMR
Yield (lbs/ac)	1433 (78%)	1846	2072 (97%)	2132	1340 (96%)	1391
Moisture (%)	8.5	8.6	10.3	10.5	13	13
Area Harv. (ac)	0.663	0.995	0.444	0.657	1.157	1.157
Dockage (%)	1.1	1.7	6.4	13.1	4.5	5.9
Bus. Wgt. (lbs/bus)	28.8	30.2	23.3	22.7	30.9	30.8
Seed Sizing (%):						
>24/64	9	2	61	62	1	1
>22/64	18	7	25	20	3	3
>20/64	26	18	10	32	14	11
<20/64	47	73	4	16	82	85
Shell (%)	50	45	47	43	46	44
Nut Meat (%)	50	55	53	57	54	56
Planted	May 8		May 17		May 16	
Harvested	September 25		October 12		October 21	



Figure 5. Wawanesa, MB Strip Trial July 27, 2022



Figure 6. Wawanesa strip trial harvest Sept 25, 2022



KNOWLEDGE TRANSFER EVENTS

As the producer organization for Manitoba sunflower growers, knowledge transfer is extremely important, MCA must demonstrate producer's check-off dollars at work. For this project, there are two specific target audiences: producers and sunflower processors/buyers.

For 2021-2022, Manitoba Crop Alliance continued to adjust our knowledge transfer events due to COVID-19. Year 4 progress on the Development of Long-Type Confection Sunflower Hybrids project was communicated with members and industry representatives through various methods:

- Seasonal tweets throughout the growing season
Twitter: @mbcropalliance
Heads Up newsletter
- Fall 2021 – Processor Tour
- Fall 2021—Walk the Plots video: <https://www.youtube.com/watch?v=lw5N9-Q-qHU&t=5s>
- February 2021—Focal Point magazine article: Broad Shoulders mailed to all MCA members.
- February 2021—MCA Annual Report

