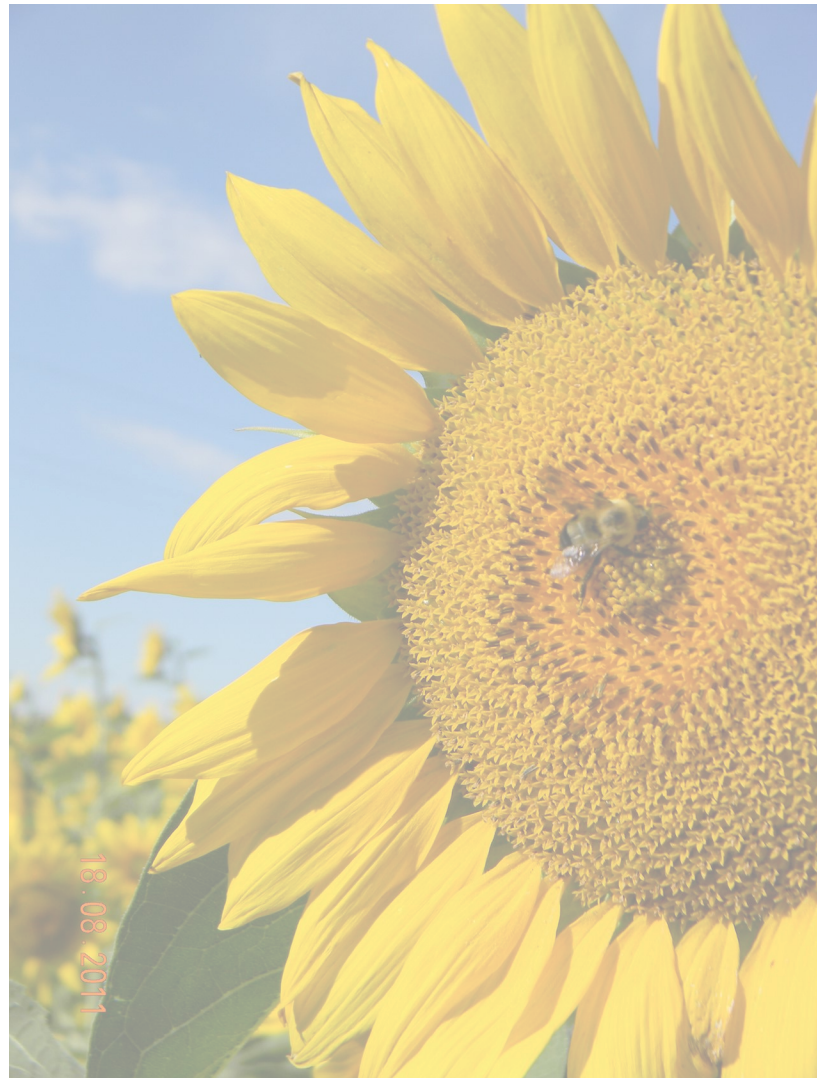




MANITOBA
CROP
ALLIANCE

2020-2021 Development of Long-Type Confection Sunflower Hybrids



YEAR 3: 2020-21

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 high 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 2020 summer nursery was planted near Fargo, North Dakota with a total of 2,080 rows.

The goals for the 2020 nursery included:

- Growing out and fine tuning the males and female AxB lines used to make the 2020 preliminary nursery hybrids;
- Advance and identify several new A x B lines for potential use in making 2021 preliminary hybrids;
- Advance and identify several new males with genes for downy mildew and rust resistance for potential use in making 2021 preliminary hybrids;
- Carry out a small multiplication of the male and female parent lines used in the 2019 strip hybrid EX43400 for potential use in a future pilot production.;
- Tissue sampled 450-500 plants for SNP marker screening
- Continue to develop new breeding populations for development of female parent lines containing genes for downy mildew and rust resistance.

Activity 1 met its Year 3 (2020-21) 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 (20)
- Finished male restorer lines - no dominant disease resistance genes. Semi- Elite (30)
- Finished male restorer lines fixed for gene PL_{ARG} or PL_{ARG} and R_{12} Elite (25)
- Finished male restorer lines fixed for gene PL_{ARG} or fixed for both PL_{ARG} and R_{12} . Semi-Elite (35)
- Finished female A x B lines with cytoplasmic male sterile conversion completed. Elite (22)
- Finished female A x B lines with cytoplasmic male sterile conversion completed. Semi-Elite (28)

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

Development of Male Restorer Lines:

SUMMER 2020

- Plants were selected from F_2 populations. Selected F_2 plants were rated for agronomics and seed type
- Tissue samples were taken from the top rated F_2 plants and marker screened for dominant disease resistance genes.
- F_3 plants were selected and bagged in the winter nursery (Chile) based primarily on earliness and plant type.
- F_4 plants were bagged at R8. The bagged F_4 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 2020-21

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

Development of Female A x B Lines:

SUMMER 2020

- 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 were advanced to winter nursery based on agronomics and seed type.
- F₄ plants were selected based on earliness and plant type with a third backcross made to cytoplasmic male sterility.
- The top rated F₄ plants were advanced to the winter nursery based on agronomics and seed type.

WINTER 2020-21



- F₃ plants were selected based on earliness and plant type and a first backcross was made to cytoplasmic male sterility.
- F₅ plants were selected based on earliness and plant type with a fourth backcross made to cytoplasmic male sterility. If female conversion to sterility was completed, the new female A x B line was used to make experimental hybrids for testing in the 2021 summer nursery.

Deliverables met

- 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 (PL_{ARG}).
- Screened material for the herbicide tolerance gene SU-7.
- Collected agronomic ratings on maturity, lodging, height, disease and a general visual screening of materials.

Figure 1: 2021 Chile Winter Nursery

HERBICIDE TOLERANCE SCREENING

All parent lines in the MCA program contain the SU-7 trait that is a single dominant gene from DuPont that conveys herbicide tolerance to tribenuron in sunflower. Both the summer and winter nurseries are sprayed with a 2x rate of tribenuron to confirm the presence of the trait within the hybrids. Any hybrids that show injury are discarded.

DOWNY MILDEW, RUST AND SCLEROTINIA SCREENING

Breeding activities in the male parent program include the incorporation of genes for disease resistance (downy mildew: PL_{ARG}, 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 2020-21 winter nursery

62 new herbicide tolerant male restorer lines (F₅) that were fixed for downy mildew resistance were identified. 24 of these lines were used in the winter breeding nursery to make experimental hybrids for testing in 2020 and were advanced to activity 2. SNP marker information confirmed that 12 of the new male restorer lines were also fixed for genes for rust resistance.

Based on agronomics, seed type and SNP marker information obtained from individual plants, 15 new F₅ female lines were identified that contained genes for downy mildew and/or rust resistance and were advanced to the 2020-21 winter nursery. Conversion to cytoplasmic male sterility (CMS) of the 15 new female lines was initiated in the 2018-19 winter nursery. CMS conversions were completed in the 2020 summer nursery. The 15 new female lines containing genes for resistance were advanced to the 2020-21 winter nursery and were used to make experimental hybrids for testing in Manitoba in 2021.

Currently in the program, there are approximately 175 finished parent lines that have been utilized to make experimental hybrids used for testing in Canada (113 males, 62 females) since the program started testing herbicide tolerant hybrids in 2014. All 175 lines are herbicide tolerant and have been advanced through the program based on solid agronomics, seed type and adaptability to Canadian growing conditions. 71 of the male lines contain genes for resistance to downy mildew, or downy mildew and rust.

DISCUSSION

Based on comparative yields and seed types obtained from experimental hybrids tested in Manitoba in 2020, it appears that 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.



Figure 2. Seed types vs. commercial check

ACTIVITY 2: SUMMER AND WINTER NURSERY

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 20 (Elm Creek) and May 20 (Holland)

The MCA transports our planting equipment from Fargo, ND in order to plant our nursery. 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 tested at 2 locations in Manitoba. Each location had two rows and was replicated twice. The trials included two commercial performance checks (6946 DMR & Panther DMR) and 1 SU-7 herbicide check (P63ME70). The 2 commercial performance checks are not tolerant to the SU-7 herbicide, so they were strategically placed



Figure 3: Preliminary nursery in Holland, MB July 2020

along the edges of the trials. They were sprayed with conventional herbicides and hand-weeded if needed.

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 (R_{12})

- 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 (Elm Creek) and October 7th (Holland). The harvested sunflower seed had to be dried before samples could be weighed. The seed from the plots was cleaned, weighted for yield and bushel weights on October 20th and 21st.

Of the 132 new preliminary lines tested in 2020, 29 were taken to harvest and evaluated for yield, agronomic and seed quality traits. Based on the overall performance along with seed quality, 12 hybrids were selected for the next level of testing in 2021. Seed of the selected 12 hybrids was produced in the 2020-2021 winter nursery in Chile for trialing in Manitoba in 2021.

Variety Performance Trials (VPT)

Three elite hybrids were tested in the VPTs that were located at 4 locations in Manitoba in 2020. These locations were: Melita, Carberry, Rossendale, and Elm Creek. All 4 locations were planted; however, one location was lost due to high cutworm pressure at emergence. A dry, cool spring also slowed emergence and lead to more damage from cutworms. All 4 locations were sprayed with at least one application of an insecticide. The 3 remaining trials were taken to harvest. The complete set of trial results were published on the MCA website at <https://mbcropalliance.ca/resources/sunflowers> in December 2020.

The three MCA hybrids (EX 35957; EX 400057; EX 57101) tested were higher in yield compared to the check; maturity was the same as the check or earlier maturity by 4 days and have overall bigger seed sizing.

TABLE 1 : 2020 VARIETY PERFORMANCE TRIAL RESULTS

SUNFLOWERS - NON-OIL 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 (days to R9)	Height (inches)	2020 Seed Sizing (%) ²		
							>22/64	>20/64	<20/64
Nuseed Americas	6946 DMR	DM	28	100	0	0	19	36	45
Nuseed Americas	Panther DMR	DM	36	100	0	-2	69	23	8
Experimental lines tested/proposed for registration in Canada									
CHS	RH1121	Conventional	3	121	2	5	72	19	9
CHS	RH208-EX	ExSun	3	114	4	1	63	24	13
MCA	EX 35957	ExSun	3	123	-4	4	72	20	8
MCA	EX 40057	ExSun	3	108	0	2	69	22	9
MCA	EX 57101	ExSun	3	109	0	4	73	20	7
CHECK CHARACTERISTICS									
6946 DMR			28	3114	122	67			
			site years	lb/ac	days	inches			
1 Genetic traits include CL = Clearfield tolerance; ExSun = Express tolerance; DM = Downy Mildew Resistance.									
2 Totals may not add to 100% due to rounding; information based off two sites at Elm Creek and Rossendale.									
Refer to the MCA website at www.mbcropalliance.ca for more details.									

Pre-

Commercial Strip Trial Testing

One elite hybrid from the 2019 Preliminary Nursery was advanced and tested at 3 locations within Manitoba in a head-to-head, field scale comparison with the commercial hybrid, 6946 DMR. A fourth location was planned but due to late arrival of seed in Manitoba from the winter nursery the producer had finished planting his sunflowers. The strips were a minimum of 8 rows wide by at least 1000' long. The hybrid in the strip trials are treated using the producer's commercial scale equipment and production practises for confection sunflowers. The trial was managed by the producer throughout the entire growing season. Agronomic data was collected on all the strip trials throughout the growing season. Both the elite hybrid and commercial hybrid were harvested with a weigh wagon capturing the yield. Seed samples were collected for further seed quality analysis (visual appearance, test weight, seed sizing, % nut meat).

Both the trials at the Baldur and Dundonald locations were planted on 30" row spacings. The Bagot site was planted using 22" row spacing. All three locations received about 70% of Normal Accumulated Precipitation for May 1 until September 30, the Dundonald location being the driest. Both hybrids were noticed to have wilting at bloom timing. The Baldur site experienced some weed competition in the strip trial, related to a short supply of the herbicide Assert in the market. 6946 DMR is a conventional hybrid for weed control. With the dry growing season, disease incidence in the trials was very low. All the trials were harvested. Over the winter months, the results of the strip trials (Table 2) along with seed samples were passed along to local seed processors to gauge interest in the elite hybrid. From the results in the small plot and the strip trial programs, the experimental hybrid, EX 35957 will be continued in 2021/2022 season for continued evaluation.



Figure 4. Dundonald, MB Strip Trial. Check (L) EX 35957 (R)

TABLE 2: 2020 PRE-COMMERCIAL STRIP TRIAL RESULTS

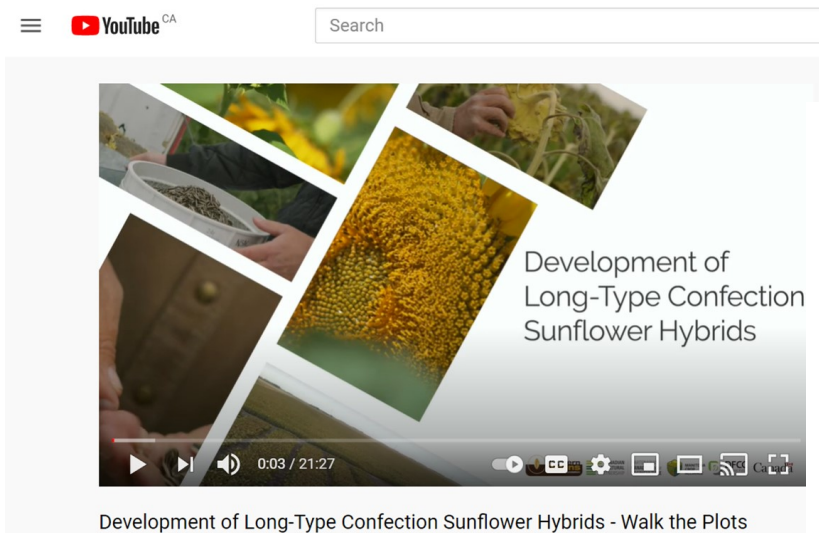
2020 Sunflower Pre-Commercial Strip Trial Results						
	Baldur, MB		Bagot, MB		Dundonald, MB	
	EX 35957	6946 DMR	EX 35957	6946 DMR	EX 35957	6946 DMR
Yield (lbs/ac)	2962 (109%)	2719	3302 (111%)	2984	3312 (89%)	3728
Moisture (%)	12.5	13.4	12.5	12.5	11.0	11.2
Area Harv. (ac)	1.26	1.89	1.26	1.26	0.89	0.68
Dockage (%)	5.3	9.1	6.7	7.5	10.1	16.5
Bus. Wgt. (lbs/bus)	25.4	24.3	24.0	21.3	27.4	29.7
Seed Sizing (%):						
>24/64	42	10	31	10	8	0
>22/64	38	37	45	43	26	2
>20/64	15	37	18	36	39	24
<20/64	5	17	6	11	28	73
Planted	May 26		May 28		May 19	
Harvested	October 8		November 3		October 19	

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 2020-2021, Manitoba Crop Alliance adjusted our knowledge transfer events due to COVID-19. Year 3 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 2020—Walk the Plots video: <https://www.youtube.com/watch?v=K1kLvlbjA0>
- February 2021—Focal Point magazine article: Broad Shoulders
Mailed to all MCA members.
- February 2021—MCA Annual Report



Development of Long-Type Confection Sunflower Hybrids - Walk the Plots



BROAD SHOULDERS

Research aimed to provide sunflower farmers with new varieties well-suited for confectionary markets

Sunflower farmers in Manitoba will soon be able to access much-improved hybrid cultivars thanks to nine years of breeding efforts. Part of a longer project that began with the National Sunflower Association of Canada, research has now been incorporated into the Manitoba Crop Alliance. Michael Hagen of CanSun LLC in Fargo, North Dakota, works on the development of the hybrid cultivars which are herbicide-tolerant, high-yielding and carry genetic resistance to the major sunflower diseases in Canada. These new cultivars also have longer seed types, carry a broad shoulder, have high test weights and meat-to-hull ratios.

In 2020, 132 preliminary hybrids and 12 advanced hybrids were selected

for testing in two Manitoba trial locations. From a total of 144 hybrids, 12 were selected for advanced trials and all contain genes for resistance to downy mildew and/or rust, with four hybrids resistant to both downy mildew and rust. Currently, the program carries 89 male lines and 47 female lines which are all herbicide-tolerant. The new lines are all tested against yield checks 6946 DMR and Panther DMR and herbicide check P63ME70. All hybrids selected for advancement in 2020 showed yield performance similar to, or greater than the check hybrids and test weights were all 25 pounds or greater. Several advanced hybrids showed exceptional meat-to-hull ratios exceeding 60 per cent nutmeat.

Lead Researcher
Michael Hagen

Sunflower Breeder
for CanSun LLC

Researcher Mike Michael Hagen has 35 years of experience in sunflower breeding and seed production.

Hagen began developing confectionary and oilseed sunflower hybrids in 1986. In 2011, Hagen joined with the National Sunflower Association of Canada to develop a Canadian confectionary breeding program. Hagen operates under the company of CanSun LLC, based in Fargo, North Dakota.

Collaborators: Darcelle Gisham and David Biss.



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