USDA-ARS Sugarbeet Releases and Breeding Over the Past 20 Years

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ABSTRACT

In 1995, Devon Doney published a comprehensive list of germplasm releases, breeding lines, and hybrids that had been developed by USDA ARS plant breeders. Doney's summary has been valuable in documenting the wide range of activities that resulted in useful germplasm resources as well as defining actual germplasm that has contributed to a sustained and profitable sugar beet industry. This report includes Doney's summary tables, as well as updates and extends the list of germplasm resources released over the past 20 years. The purpose and focus of the ARS public breeding effort has changed over the last 75 years from developing and releasing open pollinated cultivars and then hybrid cultivars to a focus on pre-breeding of enhanced germplasm. What has not changed is the close collaboration that the ARS public plant breeders have with private industry breeders. This report details the breadth of germplasm enhancement activities of the five ARS locations currently releasing enhanced germplasm (East Lansing, MI; Fargo, ND; Fort Collins, CO; Kimberly, ID; Salinas, CA). It places these activities in a broader context than often communicated in formal germplasm release notices or germplasm registration articles. Recent germplasm releases are freely available from their developers through the USDA-ARS National Plant Germplasm System. Some of the older germplasm described here may not be directly available, however much of this germplasm has been the foundation of current enhanced germplasm and the

genetic resources related to particular traits are widely deployed. New efforts to expand this germplasm base are a hallmark of current work at each of the five locations.

Keywords: pre-breeding, germplasm enhancement, plant breeding, germplasm registration, crop wild relatives (CWR)

INTRODUCTION

Devon Doney (1995b) published a list of over 800 documented releases and developments of sugarbeet (*Beta vulgaris* L.) cultivars, germplasm, hybrid parents, and genetic stocks produced by public plant breeders employed by the USDA-ARS. This was done in collaboration with all of the active ARS breeders and was a project requiring 4 years of research and compilation. At this time there was consolidation of field stations and researchers working on sugarbeet. Now, 20 years later, the beet sugar industry, and the ARS research that supports it, is going through another transition and the goals of ARS sugarbeet research programs have been refocused to reflect the changes in plant breeding due to consolidated seed companies, molecular biology, marker aided selection, genomics, and a genetically enhanced crop (Panella et al., 2014).

Public sugarbeet breeding is unique in the United States because all of the public plant breeders are ARS researchers, who collaborate within a network of ARS, university, and private industry scientists in the United States and around the world. The developments and releases become part of the public wealth and there is open-access of germplasm to all interested parties. Five ARS locations currently are involved in developing and releasing enhanced sugarbeet germplasm. Typically these populations have superior resistance to different pests and diseases. The five locations are East Lansing, MI; Fargo, ND; Fort Collins, CO; Kimberly, ID; and Salinas, CA. Much of this work has done in collaboration with B. Hellier at the USDA-ARS Western Regional Plant Introduction Center at Pullman, WA, who curates the *Beta* collection housed there. These programs and all USDA-ARS sugarbeet research are strongly supported by the beet sugar industry through the Beet Sugar Development Foundation and regional grower's associations.

This paper briefly describes the breeding activity at the five locations and updates the list of germplasm released by the USDA-ARS breeders. This list will provide in a single site the most user-friendly database from which to do a search for useful germplasm and traits. All germplasm mentioned in the text is referenced with citations in Table 2 unless otherwise noted. Table 1 lists all of the abbreviations used in Table 2 to describe the germplasm. Although documenting the releases was an easier task for us than it was for Doney, his words still ring true: "While it is difficult to quantify the impact USDA-ARS sugarbeet releases have had on the sugarbeet industry, it is obvious that they have been a major factor in its survival and stability in the US and in the World" (Doney, 1995b).

Table 1. The USDA-Agricultural Research Service sugarbeet releases by location and year are presented in Table 2 where all available codes (NSSL, PI, Crop Science Registration Numbers), citations, and brief descriptions are given. Numbers with W6 and A(mes) prefixes are Western (Pullman) and North Central (Ames) Regional Plant Introduction numbers, respectively. Below are the codes and abbreviations used in Table 2.

Abbreviation	Description
4n	Tetraploid (4n = 36, 2n = 2x = 18 diploid, 3n = 27 triploid)
Aa	Segregating for genetic male sterility (Mendelian, AA = fertile, aa = sterile)
Bb	Segregating for biennial (BB = annual, bb = biennial)
cms	Cytoplasmic [Genetic] male sterility (cms-XZ = ms cytoplasm, segregating for restorer genes; N = normal)
Hgca	High sugar yield combining ability (root yield x % sucrose)
Hsugar	High sugar content
Mm	Segregating monogerm (MM = multigerm, mm = monogerm)
ms	Male sterility (source unknown)
NB	Non-bolting tendency
O-type	CMS Non-restorer = maintainer line
Rr	Segregating for hypocotyl color (RR = red, rr = green)
seg	Segregating
sel	Selection for trait identified
SF	Self-fertile, self-compatible
SR	Smooth root, low soil tare
SS	Self-sterile, self-incompatible
SSD	Single seed descent selection
Aphan	Aphanomyces resistance
BM	Beet mosaic virus resistance (*Bm gene*)
BChV	Beet chlorosis virus
CR	Cercospora leaf spot resistance
CT	Curly top virus resistance
DM	Downy mildew resistance
Emp	Empoasca resistance, stay green under Emp infestation
Erw	Erwinia resistance
Fus	Fusarium stalk blight resistance
FOB	Fusarium yellows resistance
LIY	Lettuce infectious yellows virus resistance
LS	Cercospora leaf spot resistance
NaCl	Salt tolerance
Nema	Beet cyst nematode resistance (*Heterodera schachtii*)

P. betae	*Polymyxa betae* resistance
PM	Powdery mildew quantitative resistance, (*Pm gene*)
RA	Root aphid resistance
Rhizoc	Rhizoctonia root rot resistance
RKN	Root knot nematode resistance (*Meloidogyne spp.*)
RZ	Rhizomania resistance (*Rz#* gene)
Scler	*Sclerotium rolfsii* resistance
St Resp	Storage respiration resistance
St Rot	Storage rot resistance
VY	Virus Yellows (includes BWYV, BChV, BMYV, and BYV) resistance

CS	Crop Science
ASSBT	Proceedings or Journal of American Society of Sugar Beet Technologists
SBR	Sugarbeet Research Annual Report to BSDF (Blue Book)
SBR:CD	Sugarbeet Research Annual Report to BSDF (Blue Book) on CD
AA	Advances in Agronomy
JPR	Journal of Plant Registrations
JSBR	Journal of Sugar Beet Research
NSSL	National Seed Storage Laboratory, Fort Collins, CO
NCGPR	National Center for Genetic Resources Preservation (formerly NSSL)

Bvm	*Beta vulgaris* spp. *maritima*
C	Accessions from Salinas, CA
CT	Curly top, Salt Lake City, UT
EL	Accessions from East Lansing, MI
F	Accessions from Fargo, ND
FC	Accessions from Fort Collins, CO
gp	Germplasm
K	Accessions from Kimberly, ID
L	Accessions from Logan, UT
M	Meloidogyne resistance, Yu, Salinas, CA
PI	Plant Introduction
popn	Population
S	Savitsky, Salinas, CA
SLC	Accessions from Salt Lake City, UT
SP	Accessions from Beltsville, MD and East Lansing, Sugar Plant Investigations
SR	Smooth root, East Lansing, MI
WB	Wild beet, usually sea beet, *Bvm*

Table 2. USDA-Agricultural Research Service sugarbeet releases by location and year. Available codes (NSSL [now NCGRP], PI), Crop Science Registration Numbers, citations and brief descriptions are given. Numbers with W6 and A(mes) prefixes are Western and North Central Regional Plant Introduction numbers, respectively. Releases before 1995 were first listed by Doney (1995).

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
				U.S. NUMBERS		
1933				USDA Tech. Bul. 360	US 1	MM, CT
1936				USDA CIR 513	US 34	MM, CT
1936	4718	590580		USDA CIR 391	US 33	MM, CT, Hsugar
1937					US 217	MM, LS
1938				USDA CIR 513	US 10	MM, CT
1939					US 14	MM, CT
1939					US 12	MM, CT
1940	103046	590678			US 201	MM, LS
1940					US 200	MM, LS
1940				ASSBT 2:165-168	US 200 x 215	MM, LS
1940					US 215	MM, LS
1941				ASSBT 4:364-380	US 216	MM, LS, Aphan
1941				ASSBT 5:166-170	US 215 x 216	MM, Aa, LS, Aphan
1942				ASSBT 5:179-180	US 22	MM, CT
1948				ASSBT 5:179-180	US 22/2	MM, CT
1948	141993	590708		ASSBT 5:179-180	US 22/3	MM, CT
1948				ASSBT 5:181-186	US 56	MM, CT, NB, DM
1948	W6 17103				US 41	MM, CT, (from US35 X US22/3)
1949	4720	590582		ASSBT 5:181-186	US 56/2	MM, CT, NB, DM
1950	4719	590581		ASSBT 6:208	US 15	MM, CT, NB, DM
1952				ASSBT 6:209-217	US 226	MM, LS
1952					US 216 x 226	MM, LS, Aphan
1952	4728	590586		ASSBT 7:384-386	US 75	MM, CT, NB, DM
1952					US 225	MM, LS
1952					US 225 x 226	MM, LS,
1954	4721	590583			US 35	MM, CT, Hsugar
1954				ASSBT 8:112-117	US 400	MM, LS, Aphan
1954	4727			AA 7:89-139,1955	US 22/4	MM, CT, SS
1954	4724	590584		ASSBT 8:64	US 35-0	MM, CT, Aa, Hsugar
1958					US 104	MM, CT, LS
1960				SRB 1960:8	US 401(4n)	MM, LS, Aphan, 4n
1960	W6 17102				US 401	MM, LS, Aphan
				HYBRID RELEASES		
1960				ASSBT 11:500-506	US H2	MM, CT, NB, [(NB1cms x NB3)xC663]
1960				ASSBT 11:500-506	US H3	MM, CT, NB, [(NB1cms x NB3) x C586]
1960				ASSBT 11:500-506	US H4	MM, CT, NB, [(NB1cms x NB2) x C586]
1960				ASSBT 11:500-506	US H5A	MM, CT, NB, [(NB1cms x NB4 x C586]
1960				ASSBT 11:500-506	US H5B	MM, CT, NB, [(NB1cms x NB4) x C663]
1964					US H6	MM, CT, NB, [(NB1cms x NB5) x C663]

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1964					US H7	mm, CT, NB, [(C562cms x C569) x C663]
1964					US H7A	mm, CT, NB, [(C562cms x C546) x C264]
1964		631354	5	CS 11:942	US H8	mm, CT, NB, [(C562cms x C569) x NB7]
1968			1	CS 11:942	US H20	mm, LS, Aphan, [(SLC129cms x SLC133) x SP6322-0
1968			2	CS 11:942	US H9A	mm, CT, VY, NB, [(C562cms x C569) x C13]
1968			3	CS 11:942	US H9B	mm, CT, VY, NB, [(C562cms x C546) x C13]
1971			4	CS 11:942	US H10A	mm, CT, VY, NB, [(C562cms x C569) x C17]
1971	CSR 395		6	CS 14:340	US H10B	mm, CT, VY, NB, [(C562cms x C546) x C17]
1973					US H21	mm, LS, Aphan, [SP69550-01 x SP6322-0], Hsugar
1979					US H11	mm, CT, VY, NB, Erw, (C562cms x C546) x C36]
1981					US H20A	mm, CT, LS, Aphan, [(EL44CMS{SLC129CMS)xEL45{SL133})xSP6822-0]
1981					US H23	mm, CT, LS, Aphan, [(SP6926-01 x EL45{SL133}) x EL40]
				BELTSVILLE RELEASES		
Parent Lines						
1964	114616		PL 15	CS 21:637-638	SP6926-0	mm, LS, Aphan, O-type, SF
1964	114614	590698	PL 16	CS 21:637-638	SP6926-01	mm, LS, Aphan, cms
1968	W6 17143	615525	PL 7	CS 11:947	SP6322-0	MM, LS, Aphan, SS
1973	W6 17145		PL 8	CS 14:343	SP69550-0	mm, LS, Aphan, O-type, SF
1973	W6 17146		PL 9	CS 14:343	SP69550-01	mm, LS, Aphan, cms
Germplasm						
1956				SBR 1956:10	SP5510-0(WC6200)	MM, LS Hsugar
1956				SBR 1956:10	SP5512-0(WC6201)	
1956				SBR 1956:9	SP5517-0	MM, LS, Aphan
1956				SBR 1956:9	SP55206-0	MM, LS
1956				SBR 1956:11	SP554-0	MM, LS, CT
1956				SBR 1956:11	SP555-0	CT, LS, Aphan
1956				SBR 1956:10	SP55600-01	MM, LS, Aphan
1956				SBR 1956:10	SP557-0	MM, seedling vigor
1956				SBR 1956:11	SP558-0	MM, Aphan
1956				SBR 1956:10	SP5611-0	MM, LS
1956				SBR 1956:11	SP5651-0	MM, CT, LS, Aphan
1956				SBR 1956:11	SP566-0	mm, LS, Aphan
1957				SBR 1957:10	SP571-0	MM, LS, CT
1957				SBR 1957:10	SP57102-0	MM, LS, CT
1957				SBR 1957:8	SP5713-0	MM, LS, synthetic
1957				SBR 1957:9	SP5714-0	MM, LS, synthetic
1957				SBR 1957:9	SP5716-0	MM, LS, Aphan, synthetic
1957				SBR 1957:9	SP571850-00	MM, LS, Aphan, botrytis resistant
1957				SBR 1957:9	SP5733-0	mm, LS, synthetic
1957				SBR 1957:9	SP5734-0	mm
1958				SBR 1958:12	SP581-0	MM, LS, CT
1958				SBR 1958:11	SP5831-0	mm, LS , Aphan
1958				SBR 1958:11	SP5834-0	mm, LS
1958				SBR 1958:11	SP5835-0	mm, LS, Aphan
1958				SBR 1958:11	SP5836-0	mm, LS
1958				SBR 1958:12	SP586-0	MM, LS, CT

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1959				SBR 1959:10	SP591-0	MM, LS, CT, Aphan
1959				SBR 1959:10	SP59300-0	mm, LS, Aphan
1959				SBR 1959:10	SP5931-0	mm, LS, Aphan
1959				SBR 1959:11	SP59E5-0	mm, LS
1960				SBR 1960:11	SP5822-0	MM, LS, Aphan
1960				SBR 1960:10	SP601000-0	mm, LS, Aphan, St Rot, SS
1960				SBR 1960:11	SP60300-0	mm, LS, Aphan
1960				SBR 1960:11	SP6045-0	mm, LS, Aphan
1961				SBR 1961:10	SP60194-01	mm, LS, Aphan
1961				SBR 1961:10	SP6121-0	mm, LS, Aphan, O-type
1961				SBR 1961:10	SP6121-01	mm, LS, Aphan, cms
1961				SBR 1961:10	SP6161-0	mm, LS, Aphan
1961				SBR 1961:10	SP6162-0	mm
1962				SBR 1961:10	SP6223-0	mm, LS, Aphan, O-type
1962				SBR 1962:9	SP6223-01	mm, LS, Aphan, cms
1963				SBR 1962:9	SP61151-0	MM, LS, good quality
1963				SBR 1963:13	SP6122-0	MM, LS, good quality
1963				SBR 1963:13	SP6256-0	MM, LS, Aphan
1963				SBR 1963:13	SP63194-0	mm, LS
1963				SBR 1963:12	SP63196-0	mm, NB
1963				SBR 1963:13	SP6323-0	mm, LS, Aphan, O-type
1963				SBR 1963:14	SP6323-01	mm, LS, Aphan, cms
1963				SBR 1963:14	SP63624-0	mm, LS
1964				SBR 1963:13	SP64194-0	mm, LS, good quality
1964				SBR 1964:11	SP6423-0	mm, LS, Aphan, O-type
1964				SBR 1964:11	SP6423-01	mm, LS, Aphan, cms
1964				SBR 1964:11	SP6426-0	mm, near O-type
1964				SBR 1964:11	SP6426-01	mm, cms
1964				SBR 1964:11	SP6427-0	MM, Aphan
1965				SBR 1964:11	65100-055	mm, LS, Aphan
1966				SBR 1965:12	SP663448-01	mm, LS, Aphan, cms
1966				SBR 1966:12	SP663465-01	mm, LS, Aphan, cms
1967				SBR 1966:12	SP661017-0	MM, LS, CT, Hsugar, 4n, SS
1967				SBR 1967:12	SP661018-0	MM, LS, CT, Hsugar, 4n, SS
1967				SBR 1967:12	SP661019-0	MM, LS, CT, Hsugar, 4n, SS
1967				SBR 1967:12	SP661020-0	MM, LS, CT, Hsugar, 4n, SS
1967				SBR 1967:12	SP661021-0	MM, LS, CT, Hsugar, 4n, SS
1967				SBR 1967:12	SP661022-0	MM, LS, CT, Hsugar, 4n, SS
1967				SBR 1967:12	SP661023-0	MM, LS, CT, 4n, SS
1967				SBR 1967:13	SP661024-0	MM, LS, CT, 4n, SS
1967				SBR 1967:13	SP661025-0	MM, LS, CT, 4n, SS
1967				SBR 1967:13	SP661026-0	MM, LS, CT, 4n, SS
1967				SBR 1967:13	SP67503-01	mm, LS, Aphan, cms
1967				SBR 1967:14	SP67519-01	mm, LS, Aphan, cms
1967				SBR 1967:14	SP67547-01	mm, LS, Aphan, cms
1967				SBR 1967:15	SP67550-01	mm, LS, Aphan, cms
1967				SBR 1967:15	SP67552-01	mm, LS, Aphan, cms
1967				SBR 1967:15	SP67555-01	mm, LS, Aphan, cms

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1968					SP67599-0	mm, LS, Aphan, O-type
1968					SP67599-02	mm, LS, Aphan, cms
1969					SP67585-01	mm, cms
1969					SP683301-01	mm, cms
1970					SP7042-0	mm, LS, Aphan, O-type
1970					SP7042-01	mm, LS, Aphan, cms
1971					SP6528-01	MM, LS, Aphan
1971					SP67547-0	mm, LS, Aphan, O-type
1971					SP69523-0	mm, LS, Aphan, O-type
1971					SP69523-01	mm, LS, Aphan, cms
1971					SP69543-0	mm, LS, Aphan, O-type
1971					SP69543-01	mm, LS, Aphan, cms
1971					SP69557-0	mm, LS, Aphan, O-type
1971					SP69557-01	mm, LS, Aphan, cms
1971					SP69588-0	mm, LS, Aphan, O-type
1971					SP69588-01	mm, LS, Aphan, cms
1971					SP70514-01	mm, LS, Aphan, cms
1971					SP70618-01	mm, LS, Aphan, cms
1971	101304	590666			SP70641-0	mm, LS, Aphan,
1971	101303	590665			SP70641-01	mm, LS, Aphan, cms
1972					SP72553-01	mm, LS, Aphan, cms
1974					SP74513-01	mm, LS, Aphan, cms
1975					SP73461-00	MM, LS, SR
1975					SP74571-02	mm, LS, Aphan, cms
1977	101307	590669			SP70682-0	mm, LS, Aphan, O-type
1977	101308	590670			SP70682-01	mm, LS, Aphan, cms
1977	101309	590671			SP70756-01	mm, LS, Aphan, cms
1977	101310	590672			SP73514-0	mm, LS, Aphan, O-type
1977	101311	590673			SP73514-01	mm, LS, Aphan, cms
1977	W6 17147				SP73747-01	mm, LS, Aphan, cms
1977	97657				SP74566-01	mm, LS, Aphan, cms
1977	101305	590667			SP76745-0	mm, LS, Aphan, O-type
1977	101306	590668			SP76745-01	mm, LS, Aphan, cms
1978	114613	590697			SP70756-0	mm, LS, Aphan, O-type
1978	W6 17148				SP73747-0	mm, LS, Aphan, O-type
1978					SP74566-0	mm, LS, Aphan, O-type
1979	110260	590694			SP78564-0	mm, LS, Aphan, O-type
1979	110261				SP78564-01	mm, LS, Aphan, cms
1980	114615	590699	GP-62	CS 21:748	SP8030-0	MM, LS, Aphan, SR, SS
1983					SP79626	mm, LS, Aphan, cms
1983					SP79626-0	mm, LS, Aphan, O-type
1983					SP82260-0	MM, LS, Aphan, SS
1984					SP83301-00	MM, LS, Aphan, Rr
1985	199878	590770			SP85303-0	MM, LS, Aphan, resistant to Phytophthora, Rr
1985	199879	590771			SP85320-0	mm, O-type, rr
1985	199880				SP85320-01	mm, cms, *Bvm* cytoplasm, Rr
1985	199876	590768			SP8540-0	MM, LS, Aphan, Scler
1985	199877	590769			SP8541-0	MM, Scler

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1985	199881	590772			SP85576-0	mm, LS, Aphan, O-type, rr
1985	199882				SP85576-01	mm, LS, Aphan, cms, rr
1985	199883	590773			SP85590-0	mm, LS, Aphan, O-type, rr
1985	199884				SP85590-01	mm, LS, Aphan, cms, rr
1985	199885	590774			SP85655-0	mm, LS, Aphan, O-type, RR
1985	199886				SP85655-01	mm, LS, Aphan, cms, RR
1985	199887	590775			SP85657-0	mm, LS, Aphan, O-type, rr
1985	199888				SP85657-01	mm, LS, Aphan, cms, Rr
1985	199889	590776			SP85700-0	MM, LS, Aphan, SR
1985	199890	590777			SP85800-0	MM, high root yield, low non-sucrose solubles
1986	199891	590778			SP8531-0	MM, SR, Aphan, SS
				SALT LAKE CITY RELEASES		
Germplasm						
1950	4735	590811		ASSBT 6:191-194	SLC 003	MM, BB, BM, SF, O-type of Owen's annual cms tester
1950	4736	590812		ASSBT 6:191-194	SLC 003ms	MM, BB, BM, cms, (used as standard to test for O-type)
1956				SBR 1956:6	SLC 119	mm, LS, SF, (from US 216 x SLC 101)
1956				SBR 1956:6	SLC 121(435)	mm, CT, SF, (from US 75 x SLC 600mm)
1956	4729	590809			SLC 122	mm, CT, SF
1956				SBR 1956:7	SLC 122-0	mm, CT, Aa, SF
1956	A 2654				SLC 122-19	mm, CT
1956	4730	590810		SBR 1956:7	SLC 122ms	mm, CT, cms
1956	103027	590677		SBR 1956:6	SLC 15	mm, CT, SS
1956	183488	590741			SLC 17	
1956	183489	590742		SBR 1956:6	SLC 18(5076)	mm, CT, SS, O- type
1956	183490	590743		SBR 1956:6	SLC 19	mm, CT, SS
1956	183491	590744		SBR 1956:6	SLC 20(8370)	mm, SS (from Klein E)
1956	183492	590745			SLC 21	
1956	183493	590746		SBR 1956:6	SLC 22(8337)	mm, SS (from Klein Z)
1956	183494	590747			SLC 23	
1956				SBR 1956:6	SLC 24	mm, SS, (F_3 from CT(mm) x LSR(MM) US201)
1957				SRB 1957:5	CT5	MM, CT, Aa, SF
1957				SBR 1957:6	SLC 123	mm, CT, SF
1957				SBR 1957:6	SLC 124	mm, LS, SF
1957	182011	590734			SLC 125(8506)	mm, CT, SF
1957				SBR 1957:6	SLC 125-0	mm, CT, Aa, SF
1957				SBR 1957:6	SLC 125ms	mm, CT, (F1 of SLC125)
1957				SBR 1957:5	SLC 34(5052)	mm, CT, SS
1957	183495	590748		SBR 1957:5	SLC 35	mm, CT, SS, Erw
1957				SBR 1957:5	SLC 35ms(9333)	mm, CT, cms
1957				SBR 1957:6	SLC 36-0	mm, CT, Aa, SS
1958	W6 17106			SBR 1958:8	CT5aa	MM, CT, Aa
1958	A 2644				CT5mm	mm, CT
1958	4726	590585		ASSBT 10:525-543	CT7(SL5070+0)	MM, CT, Aa, SF
1958	182012	590735			SLC 126(6573)	
1958	182013	590736		SBR 1958:9	SLC 127(6576)	mm, CT, SF, O-type, rr
1958	182014	590859		SBR 1958:8	SLC 128(0534)	mm, CT, SF, O-type, RR
1958	182015	590860			SLC 128cms(9147)	mm, CT, cms

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1958				SBR 1958:7	SLC 340	MM, CT, 4n, SS
1958				SBR 1958:7	SLC 342	MM, CT, 4n, SS
1959	4722	590807		ASSBT 4:246-252	CT9	MM, CT, SF
1959				SBR 1960:9	SLC 129-0	mm, CT, Aa, O-type, rr
1959	A 2653			SBR 1959:7	SLC 91	mm, CT, 4n, O-type, SF
1959				SBR 1959:7	SLC 91ms	mm, CT, 4n, cms
1960	A 2651			SBR 1960:8	CT5A-0	MM, CT, Aa, O-type, SF, rr
1960	W6 17105			SBR 1960:8	SLC 0410	MM, CT, Aa, (from US 201B), SS
1960	A 2663			SBR 1960:9	SLC 133(7401)	mm, CT, rr
1960	W6 17104			SBR 1960:10	SLC 133ms(7121)	mm, CT, cms, rr
1960				SBR 1960:7	SLC S-23	mm, LS, SF, rr
1961	A 2650 &			SBR 1961:8	CT5(BC2)	mm, CT, O-type, rr
1961	A 2649			SBR 1961:8	CT5(BC2)ms	mm, CT, rr
1961	4731	590587			CT5B	mm, CT, Aa
1961	182010	590733		ASSBT 10:525-543	CT8 (7827)(L8)	CT, Hsugar
1961	A 2648			SBR 1959:8	CT9A	MM, CT, RR
1961	4723	590808		ASSBT 7:26-30	CT9ms	MM, CT, cms
1961	4733	590588			Klein E	
1961	182018	590737			SLC 130(0506)	
1961	182019	590738			SLC 131(0206)	Erw
1961	182020	590739		SBR 1961:8	SLC 132	mm, CT, VY, Erw, rr
1961				SBR 1961:7	SLC 14500	mm, BB, O-type
1961				SBR 1961:8	SLC 14500HO	mm, BB, cms
1961	4732				SLC 742	Tracy 2769, (CT susceptible check)
1961	4734	590589			SLC 9470	BB, from Munerati
1968	182016	590861		SBR 1960:9	SLC 129 (1523)	mm, CT, Aa, Erw, rr
1968	182017	590862		SBR 1960:9	SLC 129cms(0166)	mm, CT, cms
1968	182021	590740			SLC 133(7406)	mm, CT, rr
1968	182022				SLC 133(7409)	mm, CT, Erw, rr
1978	29900			ASSBT 6:156-159	SLC 101	original monogerm from Oregon field in 1948
				LOGAN RELEASES		
Germplasm						
1965				SBR 1965:10	L13	mm, CT, O-type
1968	A 2637			SBR 1968:A6	L-10T	MM, CT, 4n of CT9A
1968	A 2638			SBR 1968:A6	L-11T	MM, CT, 4n of (CT9 x CT5)
1968	A 2639			SBR 1968:A6	L-12T	MM, 4n of 289 (Hsugar line)
1968	A 2640			SBR 1968:A6	L-23T	mm, CT, 4n of SLC122-19
1968				SBR 1968:A6	L-28Tcms	mm, CT, 4n of SLC128cms, cms
1968	A 2641			SBR 1968:A6	L-33T	mm, CT, 4n of SLC133
1968	A 2642			SBR 1968:A6	L-33Tcms	mm, CT, 4n of SLC133cms, cms
1968	A 2631			SBR 1968:A5	L-3T	MM, CT, LS, Erw, 4n
1968	A 2632			SBR 1968:A5	L-4T	MM, CT, 4n
1968	A 2643			SBR 1968:A6	L-53T	MM, CT, 4n of L53
1968	A 2633			SBR 1968:A6	L-6T	MM, CT, 4n of CT5B
1968	A 2634			SBR 1968:A6	L-8T	MM, CT, Erw, PM, 4n of CT8
1968	A 2635			SBR 1968:A6	L-9T	mm, CT, 4n of CT9
1968	A 2636			SBR 1968:A6	L-9Tcms	mm, CT, 4n of CT9, cms

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1969	A 2666				AT4101	
1969				SBR 1969:A6	L-13cms	mm, CT, cms
1978	106713	590690	GP 36	CS 18:1101	L19	MM, CT, Hsugar, SF, Rr
1978	106708	590839	GP 31	CS 18:1101	L35	mm, High CT, O-type, SF, rr
1978	106709	590840	GP 32	CS 18:1101	L35cms	mm, High CT, cms, rr
1978	106710	590689	GP 33	CS 18:1101	L36	mm, CT, O-type, SF, rr
1978	106714	590691	GP 37	CS 18:1101	L37	MM, CT, SF, rr
1978	106715	590692	GP 38	CS 18:1101	L38	MM, CT, O-type, SF, rr
1978	106711	590841	GP 34	CS 18:1101	L53	MM, CT, O-type, SF, RR
1978	106712	590842	GP 35	CS 18:1101	L53cms	MM, CT, cms, RR
1978			GP 39	CS 18:1101-1102	L60	MM, LS, pollen fertile restorer, SF
1978	106716	590693	GP 40	CS 18:1101-1102	L61	mm, CT, pollen fertile restored, SF, rr
1981	162388	590725	GP 70	CS 22:698-699	L34	MM, CT, near O-type, SF, rr
1981	162389	590726	GP 71	CS 22:698-699	L40	MM, CT, O-type, SF
1981	162390	590727	GP 72	CS 22:698-699	L50	mm, CT, near O-type, SF, rr
1983	183524	590749			L8	CT, Hsugar
				EAST LANSING RELEASES		
Parent Lines						
1977	157299	590855	PL 19	CS 22:700	EL44	mm, CT, O-type
1977	157296	590856	PL 20	CS 22:700	EL44cms	mm, CT, cms
1981	157297	590719	PL 21	CS 22:700	EL40	MM, LS, Aphan, SS
1980	157298	590720	PL 22	CS 22:700	EL45/2	mm, CT, O-type
Germplasm						
1961				SBR 1961:11	EL59B18-01	mm, SS
1961				SBR 1961:13	EL60B-42	MM, LS, Aphan
1961				SBR 1961:13	EL60EL-80	MM, LS, Aphan, SR
1961				SBR 1961:11	EL61B18-0	MM, LS, frost resistant
1961				SBR 1961:11	EL61B28-01	MM, SS
1961				SBR 1961:11	EL61G1-01	mm, LS, Aphan, O-type
1961				SBR 1961:12	EL61G1x02ms	mm, cms
1961				SBR 1961:12	EL61G2-01	mm, LS, Aphan, O-type
1961				SBR 1961:12	EL61G2x02ms	mm, cms
1961				SBR 1961:12	EL61G4-01	mm, LS, Aphan, O-type
1961				SBR 1961:12	EL61G4x02ms	mm, cms
1966	W6 17107			SBR 1966:10	EL33	mm, LS, Aphan, O-type
1966				SBR 1966:10	EL33 C1	mm, LS, Aphan, cms
1966	W6 17108			SBR 1966:11	EL35	mm, LS, Aphan, O-type
1966	W6 17109			SBR 1966:11	EL35 C1	mm, LS, Aphan, cms
1966				SBR 1966:11	EL66B15-0	MM, 4n of 02 clone
1969	W6 17110			SBR 1969:A5	EL36	mm, O-type
1969	W6 17111			SBR 1969:A5	EL36 C2	mm, cms
1969				SBR 1969:A5	EL37	mm, Aphan, O-type
1969				SBR 1969:A6	EL37 C2	mm, Aphan, cms
1971	W6 17112				EL38	mm, O-type, high yield, SS, Rr
1971	W6 17113				EL38 C2	mm, cms, Rr
1972	W6 17114				EL39	MM, LS, Aphan, SS, Rr
1973					EL41	MM, LS, Aphan, SS

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1977	W6 17115				EL42	MM, LS, Aphan, Rhizoc, rr
1977	W6 17116				EL43	MM, LS, Aphan, Rhizoc, Rr
1977	157295	590718			EL45	mm, CT, O-type
1979	157300	590721			EL46	MM, high TLWR
1984		607897	GP 223	CS 43:744	EL48	mm, LS, Aphan, Rhizoc, O-type
1985	195507	610416			EL40	lines 22 & 9, LS, Aphan, SS
1985	195508	610417			EL40	lines 6 & 12, LS, Aphan, SS
1985	195504	610415			EL40	lines 30 & 18, LS, Aphan, SS
1985	195503				EL40	lines 24 & 31, LS, Aphan, SS
1985	195506	612770			EL40	lines 32 & 29, LS, Aphan, SS
1985	195505	633962			EL40	lines 15 & 27, LS, Aphan, SS
1987		598071	GP 187	CS 38:902	REL-1	Bb, Mm, Rr, SF, good shoot regenerator
1989					CR1-B	Mm, Bb, Rr, sulfonylurea resistant, SF
1990					CR1-H	Mm, Bb, sulfonylurea resistant, near O-type, SF, Rr
1990		607899	GP 215	CS 40:1834	SR87	SR, MM, LS, Aphan, SS, Rr
1992		607898			SR80	SR, MM, SS, Rr
1993					EL49	MM, SR, SF, Rr, sulfonylurea resistant
1994		598073	GP 203	CS 39:883	EL50	mm, LS, near O-type, SS
1996		598072	GP 188	CS 38:902	REL-2	Bb, Mm, Rr, SF, good shoot regenerator
1997		598074	GP 205	CS 40:586	EL51	Rhizoc, LS, Aphan, Mm, Rr
1997		598075	GP 204	CS 40:304	SR93	SR, MM, Rr
1997		598076	GP 202	CS 39:297	SR94	SR, MM, Rr, Hsugar, LS, Aphan
1998		603947	GP 208	CS 40:1205	SR95	SR, MM, Rr, Aphan
2001		628274	GP 222	CS 43:744	EL52	mm, LS, Aphan, Rhizoc, O-type
2002		628272	GP 224	CS 43:2314	SR96	SR, MM, Rr, LS, Aphan, Hsugar
2002		628273	GP 225	CS 43:2314	SR97	SR, MM, Rr, LS, Aphan, Hsugar
2003		632750	GP 238	CS 44:1032	EL0204	SR, RZ, Aphan, LS, MM, RR
2006		641927	GP 258	CS 46:2334	EL53	SR, Rhizoc, Aphan, LS, Rr, Mm
2006		643989			TBEL-1	Table beet, cylindrical shape, Hsugar, SF, Aa, RZ (Rz1), near O-type
2008		654357	GP 277	JPR 5:227	EL54	Pre-breeding (from WB879), Aphan, SF, Mm, Aa
2008		655304	GP 278	JPR 5:227	EL55	Seed storage longevity, Mm, LS, Aphan, near O-type
2009		655305			EL-X1	Pre-breeding (from WB879), Aphan, SF, Aa
2009		655306			EL-X2	Pre-breeding, Aphan, SF, Aa
2009		655307			EL-X3	Pre-breeding (from WB185), Aphan, SF, Aa
2009		655308			EL-X4	Pre-breeding (from WB879), Aphan, SF, Aa
2011		663211			EL56	NaCl
2011		663212			EL57	SF conversion, Aa, Mm, EL broad genetic base
2011		659754			SR98/2	Rhizoc, Aphan, SR, SS, Mm
2014		664913			EL58	Nema, SS, broad genetic base, Aphan
2014		664915			EL60	LS, Rhizoc, Aphan, , Mm, SS
2015		655951	GP-287	JPR 9(2):227-231	SR98	Rhizoc, SR, SS, Mm
pending		664912			EL50/2	mm, Rr, LS, Aphan, SS, Hsugar
pending		664914			EL59	Nema, broad genetic base, Aphan
pending		664916			EL61	Nema, broad genetic base, Mm, SS
pending		664917			EL62	Nema, RKN, broad genetic base, Mm, SS
pending		664918			EL63	Nema, broad genetic base, Mm, SS
pending		664919			EL64	Nema, LS, broad genetic base, Mm, SS
pending		664920			EL65	Nema, NaCl, broad genetic base, Mm, SS

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
pending		664921			EL66	Nema, broad genetic base, Mm, SS
pending		664923			SR100	Nema, SR, LS, Mm, SS
pending		664924			SR101	SR, Rhizoc, LS, Aphan, Mm, SS
pending		664922			SR99	Nema, SR, Mm, SS, Hsugar
			FARGO RELEASES			
Germplasm						
1977	110271	590695	GP 15	CS 18:358	F1001	MM, St Rot (from USSR)
1977	110272	590696	GP 16	CS 18:358	F1002	MM, St Rot, Rhizoc
1982	173975	590728	GP 85	CS 23:193	F1003	MM, St Resp
1984	189785	590763	GP 94	CS 25:577	F1004	MM, St Rot, Rr
1984	189786	590764	GP 95	CS 25:577	F1005	MM, St Rot, rr
1984	189787	590765	GP 96	CS 25:577	F1006	MM, St Rot, RR
1986		510668	GP 120	CS 28:205-206	F1007	MM, St Resp, rr
1986		510669	GP 121	CS 28:205-206	F1008	MM, St Resp, rr
1988		527307	GP 130	CS 29:836	F1009	MM, St Resp, St Rot
1988		535818	GP 131	CS 30:429-430	F1010	MM, Hsugar, Rr
1988		555454	GP 134	CS 32:1079	F1011	MM, Hsugar, RR
1988		552532	GP 135	CS 32:1079	F1012	MM, Hsugar, Rr
1988		552533	GP 136	CS 32:1079	F1013	MM, Hsugar, Rr
1988		552534	GP 137	CS 32:1079	F1014	MM, Hsugar, Rr
1994		583778	GP 160	CS 35:947	y317	MM, from B. maritima cross, cms-XZ, Rr
1994		583779	GP 161	CS 35:947	y318	MM, from B. maritima cross, cms-XZ, Rr
1994		583780	GP 162	CS 35:947	y322	MM, from B. maritima cross, cms-XZ, Rr
1994		583781	GP 163	CS 35:947	y387	MM, from B. maritima cross, cms-XZ, Rr
1996	378483.51	605413	GP 208	CS 40:867-868	F1015	MM, Sugarbeet root maggot, Rr
1998	383163.51	608437	GP 207	CS 40:867-868	F1016	MM, Sugarbeet root maggot, r
2009		656591	GP 265	JPR 4:149-154	F1017	MM, from B. maritima cross, XZ, rr
2009		658401	GP 266	JPR 4:149-154	F1018	MM, from B. maritima cross, XZ, rr
2009		656592	GP 267	JPR 4:149-154	F1019	MM, from B. maritima cross, XZ, Rr
2009		656593	GP 268	JPR 4:149-154	F1020	MM, from B. maritima cross, XZ, rr
2009		658402	GP 269	JPR 4:149-154	F1021	MM, from B. atriplicifolia cross, XZ, Rr
2009		656594	GP 270	JPR 4:149-154	F1022	MM, from B. macrocarpa cross, XZ, rr
2009		656595	GP 271	JPR 4:149-154	F1023	MM, from B. patula cross, XZ, Rr
2009		658654	GP 272	JRP 5:241-247	F1024	MM, Sugarbeet root maggot, LS, Rr
2013		671774			F1030	MM, y318/L19, rr
2013		671775			F1031	MM, y322/L19, rr
2013		671776			F1032	MM, y387/L19,Rr
Genetic Stocks						
2011		665408	GS 9	JPR 7:250-256	F1025	MM, low sodium, Rr
2011		665409	GS 10	JPR 7:250-256	F1026	MM, low potassium, rr
2011		665410	GS 11	JPR 7:250-256	F1027	MM, low amino-nitrogen, Rr
2013		668026		JSBR 50: 1-13	F1028	MM, low amino-nitrogen, RR
2013		668027		JSBR 50: 1-13	F1029	MM, high amino-nitrogen, Rr

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
				FORT COLLINS RELEASES		
Parent Lines						
1988		518779	PL 27	CS 28:1041-1042	AD-1	MM, Hsugar, SS
1988		518780	PL 28	CS 28:1041-1042	AD-2	MM, LS, Hsugar, SS
1988		518781	PL 29	CS 28:1041-1042	AD-3	MM, SF, Hsugar
1991		558513	PL 30	CS 32:1299	FC401	mm, LS, Rhizoc, O-type, SF, Rr
1991				CS 32:1299	FC401cms	mm, LS, Rhizoc, cms, Rr
1991		558514	PL 31	CS 32:1299	FC402	mm, LS, O-type, SF, Rr
1991				CS 32:1299	FC402cms	mm, LS, cms, Rr
1991		558515	PL 32	CS 32:1299	FC403	mm, Aphan, Rhizoc, O-type, SF
1991				CS 32:1299	FC403cms	mm, Aphan, Rhizoc, cms
Germplasm						
1961				SBR 1961:9	FC501	mm, LS, O-type, rr
1963	W6 17122			SBR 1963:11	FC502	mm, LS, O-type, rr
1963				SBR 1963:11	FC502cms	mm, LS, cms, rr
1963	W6 17123			SBR 1963:11	FC503	mm, LS, O-type, RR
1963	W6 17124			SBR 1963:12	FC503cms	mm, LS, cms, RR
1965	W6 17125			SBR 1965:9	FC505	mm, LS, O-type, rr
1965	W6 17126			SBR 1965:10	FC505cms	mm, LS, cms, rr
1965	W6 17127				FC601	mm, CT, LS, Aa, O-type, Rr
1965	W6 17131				FC601/1	mm, CT, LS, Aa, O-type, Rr
1965	W6 17128				FC601cms	mm, CT, LS, cms, Rr
1966	W6 17132			SBR 1966:9	FC601/2	mm, CT, LS, Aa, O-type, Rr
1966	W6 17133			SBR 1966:10	FC601/2cms	mm, CT, LS, cms, Rr
1968	W6 17129			SBR 1968:A4	FC602	mm, CT, LS, O-type, rr
1968	W6 17130			SBR 1968:A4	FC602cms	mm, CT, LS, cms, rr
1968	98270	590661	GP-1	CS 12:400	FC701	MM, Rhizoc, SS, RR
1968	W6 17136			SBR 1968:A3	FC701/2	MM, Rhizoc, SS, RR
1968	98271	590662	GP-2	CS 12:400	FC702	MM, Rhizoc, SS, Rr
1968				SBR 1968:A3	FC702/2	MM, Rhizoc, SS, Rr
1969	W6 17142			SBR 1969:A4	FC903	MM, CT, LS, NB
1971	W6 17134				FC603	mm, CT, LS, O-type, SF, rr
1971	W6 17135				FC603cms	mm, CT, LS, cms, rr
1971	W6 17140				FC801	MM, CT, LS, Rhizoc, RR
1973	W6 17139				FC703/1	MM, Rhizoc, pseudo SF, rr
1974	W6 17137				FC701/5	MM, Rhizoc, pseudo SF, RR
1974	W6 17138				FC702/5	MM, Rhizoc, pseudo SF, Rr
1975	W6 17121				FC101	MM, St Rot
1975	W6 17117				FC102	MM, LS, St Rot
1975					FC103	MM, St Rot, St Resp
1975	W6 17118				FC104	MM, St Rot, St Resp
1975	W6 17119				FC105	MM, St Rot, St Resp, SS
1975	W6 17120				FC106	Mm, St Rot
1975					FC107	mm, St Rot
1976	98272	590663	GP-11	CS 17:678	FC701/4	MM, Rhizoc, SS, rr
1976	98273	590664	GP-12	CS 17:678	FC701/4(4x)	MM, Rhizoc, 4n, SS
1976	98265	590656	GP-13	CS 17:678	FC703	MM, Rhizoc, SS, Rr

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1976	98266	590657	GP-14	CS 17:678	FC703(4x)	MM, Rhizoc, 4n, SS
1978	98164	590819	GP-44	CS 19:131	FC502/2	mm, LS, O-type, rr
1978	98163	590820	GP-45	CS 19:131	FC502/2cms	mm, LS, O-type, rr
1978	98169	590823	GP-42	CS 19:131	FC504	mm, LS, O-type, rr
1978	98170	590824	GP-43	CS 19:131	FC504cms	mm, LS, cms, rr
1978		558505	GP-46	CS 19:131	FC506	mm, LS, O-type, rr
1978	98166		GP-47	CS 19:131	FC506cms	mm, LS, cms, rr
1978		558506	GP-48	CS 19:131-132	FC604	mm, CT, LS, O-type
1978		558507	GP-49	CS 19:131-132	FC604cms	mm, CT, LS, cms
1978	98167	590821	GP-50	CS 19:131-132	FC605	mm, CT, LS, O-type
1978	98168	590822	GP-51	CS 19:131-132	FC605cms	mm, CT, LS, cms
1978	110274	590843	GP-52	CS 19:300	FC606	mm, CT, LS, O-type
1978	110273	590844	GP-53	CS 19:300	FC606cms	mm, CT, LS, O-type
1978	98267	590658	GP-55	CS 19:935	FC702/4	MM, Rhizoc, SS, rr
1978	162351	590724	GP-56	CS 19:935	FC702/4(4x)	MM, Rhizoc, 4n, SS, Rr
1978	98268	590659	GP-54	CS 19:934-935	FC704	MM, Rhizoc, red flesh, RR
1978	98269	590660	GP-57	CS 19:935	FC705	MM, Rhizoc, SS
1978	116207	590701	GP-58	CS 19:935	FC706	MM, Rhizoc, SS
1978	116208	590702	GP-59	CS 19:935	FC707	MM, Rhizoc, SS
1978	98165	590655	GP-41	CS 19:131	FC902	MM, CT, LS, Aa, SF
1979	106034	590837	GP-60	CS 20:419	FC607	mm, CT, LS, O-type
1979	106035	590838	GP-61	CS 20:419	FC607cms	mm, CT, LS, cms
1980	116205	590845	GP-63	CS 21:802	FC708	mm, Rhizoc, O-type, SF
1980	116206	590846	GP-64	CS 21:802	FC708cms	mm, Rhizoc, cms
1981	117232	590703	GP-65	CS 22:454	FC702/6	MM, LS, Rhizoc, SS
1981	162331	590722	GP-84	CS 22:1275-1276	FC703/4	MM, LS, Rhizoc, SS, Rr
1982	176212	590729	GP-87	CS 23:601-602	FC711	MM, LS, Rhizoc, SS, Rr
1983	185482	590756	GP-91	CS 25:374	FC701/6	MM, LS, Rhizoc, pseudo SF, Rr
1983	185481	590755	GP-92	CS 25:374	FC702/7	MM, LS, Rhizoc, pseudo SF, Rr
1983	185480	590754	GP-93	CS 25:374	FC705/1	MM, LS, Rhizoc, pseudo SF, Rr
1985	197097	590767	GP-98	CS 26:392	FC606(4x)	mm, CT, LS, 4n, SS
1985	197098		GP-100	CS 26:392	FC606cms(4x)	mm, CT, LS, 4n, cms
1985	197099	590871	GP-99	CS 26:392	FC607(4x)	mm, CT, LS, 4n, SS
1985	197096	590872	GP-101	CS 26:392	FC607cms(4x)	mm, CT, LS, 4n, cms
1985	194110	590766	GP-97	CS 26:213-214	FC712	MM, LS, Rhizoc, SS, Rr
1986		506238	GP-119	CS 27:822	FC707(4x)	MM, Rhizoc, 4n, pseudo SF, RR
1987		518643	GP-128	CS 28:1039	FC709	MM, LS, Rhizoc, pseudo SF, Rr
1988		518644	GP-126	CS 28:1039	FC609	mm, LS, O-type, SS, Rr
1988		518645	GP-127	CS 28:1039	FC609cms	mm, LS, cms, Rr
1990		542971	GP-133	CS 31:494	FC710	MM, Rhizoc, pseudo SF, Rr
1992		584987	GP-164	CS 35:1721	FC404	mm, BB, O-type, SF, rr
1992		584988	GP-165	CS 35:1721	FC404cms	mm, BB, cms, rr
1992		574625	GP-148	CS 34:290	FC715	mm, LS, Rhizoc, O-type, pseudo SF
1992		574626	GP-149	CS 34:290	FC715cms	mm, LS, Rhizoc, cms
1992		574627	GP-143	CS 35:291	FC716	MM, Rhizoc, cms-XZ, Rr
1992		574628	GP-144	CS 35:291	FC717	MM, Rhizoc, Rr
1992		574629	GP-145	CS 35:291	FC718	MM, Rhizoc, Rr
1992		574630	GP-146	CS 35:291	FC719	MM, Rhizoc, Hsugar (Polish), Rr

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1995	307380	591334	GP-167	CS 36:819-820	FC725	MM, LS, Rhizoc, SS, Rr
1995	307381	591335	GP-168	CS 36:819-820.	FC726	MM, LS, Rhizoc, SS
1995	307382	591336	GP-169	CS 36:819-820.	FC728	MM, LS, Rhizoc, cms-XZ, SS
1997		594910	GP-185	CS 37:1675-1676.	FC721	mm, O-type, Rr, SF, Rhizoc, LS, CT
1997		594911	GP-186	CS 37:1675-1676.	FC721cms	mm, cms, Rr, SF, Rhizoc, LS, CT
1999		599668	GP-200	CS 39:298-299.	FC709-2	MM, LS, Rhizoc, SS, Rr, Hsugar (Polish)
1999		599669	GP-201	CS 39:298-299.	FC727	MM, LS, Rhizoc, pseudo SF, Rr
2001		607379	GP-217	CS 41:1374	FC712(4X)	MM, 4n, LS, Rhizoc, SS, Rr
2004		633733	GP-239	CS 44:1885-1886.	FC710(4X)	MM, 4n, Rhizoc, pseudo SF, Rr
2004		632251	GP-228	CS 44:361-362	FC724	mm, Aa, O-type, Rr, SF, Rhizoc, LS, Hsugar
2005		634018	GP-246	CS 45:1169-1170	FC201	Mm, Aa, Rr, O-type, SF, CT, LS, Aphan, Rhizoc, *Rz1, Rz2*
2005		634210	GP-247	CS 45:2666-2667	FC301	Mm, Aa, Rr, O-type, SF, CT, LS, Aphan, *Rz1*
2005		636335	GP-250	CS 46:1009-1010	FC720	Mm, O-type, Rr, SF, Rhizoc, LS
2005		636336	GP-251	CS 46:1009-1010	FC722	Mm, O-type, Rr, SF, Rhizoc, LS
2005		636337	GP-251cms	CS 46:1009-1010	FC722CMS	Mm, cms, Rr, SF, Rhizoc, LS
2007		639917	GP-259	JPR 1:66-67	FC723	Mm, O-type, Rr, pseudo SF, Rhizoc, LS
2007		639918	GP-259cms	JPR 1:66-67	FC723CMS	Mm, O-type, Rr, pseudo SF, Rhizoc, LS
2008		651015	GP-263	JPR 2(2):146-155	FC220	MM, Rr, Aa, SF, Rhizoc, Aphan, *Rz2, Rz1*, RA
2008		651016	GP-264	JPR 2(2):146-155	FC221	MM, Rr, Aa, SF, Rhizoc, Aphan, *Rz1*, CT
2011		658059	GP-273	JPR 5(2): 233-240	FC1018	Mm, Rr, Aa, SF, *Rz1*, Rhizoc, LS, Aphan, CT
2011		658060	GP-274	JPR 5(2): 233-240	FC1019	Mm, Rr, Aa, SF, *Rz1*, Rhizoc, LS, Aphan, CT
2011		658061	GP-275	JPR 5(2): 233-240	FC1020	Mm, Rr, Aa, SF, *Rz1*, Rhizoc, LS, Aphan, CT
2011		658062	GP-276	JPR 5(2): 233-240	FC1022	Mm, Rr, Aa, SF, *Rz1*, CT, Hsugar, O-type
2013		665053	GP-282	JPR 7(2):1-9.	FC1028	Mm, Rr, Aa, SF, *Rz1*, CT, Aphan, LS
2013		665054	GP-283	JPR 7(2):1-9.	FC1036	Mm, Rr, Aa, SF, *Rz1*, Aphan, LS
2013		665055	GP-284	JPR 7(2):1-9.	FC1037	Mm, Rr, Aa, SF, *Rz1*, CT, Rhizoc LS, Aphan,
2013		665056	GP-285	JPR 7(2):1-9.	FC1038	Mm, Rr, Aa, SF, *Rz1*, CT, Rhizoc, Aphan, LS
2015		671963	GP-286	JPR 9(2):115-120	FC305	Mm, Rr, Aa, SF, *Rz1*, LS, Aphan, CT, FOB
					FC1740	MM, Rr, Aa, CT, SF, LS, *Rz1, Rz2*
					FC1741	MM, Rr, Aa, SF, CT, LS, *Rz2*,
Genetic Stocks						
1990		540886	GS-1	CS 31:248-249	Triplo 1	Trisomic for chromosome 1
1990		540887	GS-2	CS 31:248-249	Triplo 2	Trisomic for chromosome 2
1990		540888	GS-3	CS 31:248-249	Triplo 3	Trisomic for chromosome 3
1990		540889	GS-4	CS 31:248-249	Triplo 4	Trisomic for chromosome 4
1990		540890	GS-5	CS 31:248-249	Triplo 5	Trisomic for chromosome 5
1990		540891	GS-6	CS 31:248-249	Triplo 7	Trisomic for chromosome 6
1990		540892	GS-7	CS 31:248-249	Triplo 8	Trisomic for chromosome 7
1990		540893	GS-8	CS 31:248-249	Triplo 9	Trisomic for chromosome 8
1990			GS-9	CS 31:248-249	Triplo 9	Trisomic for chromosome 9
				KIMBERLY RELEASES		
Genetic stock						
2011		663862			KDH13	Doubled haploid Line, CT, mm, rr, SF
Parental Lines						
2014		672569			KEMS-09	EMS mutant, Mm, RR, Rz, SF
2014		672570			KEMS-12	EMS mutant, Mm, rr, Rz, SR, SF, Hsugar

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
				SALINAS RELEASES		
Parent Lines						
1958		see610315		SBR, 1968:9	C8569HO,C569cms	mm, CT, NB, DM, cms, see C569cms
1968	98144	590642	PL 5	CS 11:946-947	C13	MM, CT, VY, NB, DM, SS, rr, pollinator of USH9
1968	98155	590649	PL 4	CS 11:946-947	C546	mm, CT, NB, DM, Erw, SF, rr, O-type of USH7B,8B,9B,10,&11
1968	142000	590847	PL 1	CS 11:946-947	C562, 0562	mm, CT, NB, DM, SF, O-type, rr
1968	142001	590848	PL 2	CS 11:946-947	C562cms	mm, CT, NB, DM, cms, cms of USH7,8,9,10,&11
1968	98153	590648	PL 3	CS 11:946-947	C569	mm, CT, NB, DM, SF, O-type, 0-type of USH7A,8A,&9A
1971	98162	590654	PL 6	CS 11:946-947	C17	MM, CT, VY, NB, DM, SS, rr, pollinator of USH10
1976	98151	590647	PL 12	CS 17:678	C551	mm, CT, NB, DM, SF, O-type
1976	98145	590813	PL 10	CS 17:678	C563	mm, CT, NB, DM, SF, O-type, rr
1976	98147	590814	PL 11	CS 17:678	C563cms	mm, CT, NB, DM, cms, cms of commercial hybrids
1977	103054	590681	PL 14	CS 18:920	C02	MM, CT, VY, NB, Erw, SS, rr
1977	103055	590682	PL 13	CS 18:920	C36	MM, CT, VY, NB, DM, Erw, SS, rr, pollinator of USH11
1980	162333	590857	PL 17	CS 22:454	C566	mm, CT, Fus, NB, SF, O-Type, Fus selection C563
1980	162334	590858	PL 18	CS 22:454	C566cms	mm, CT, Fus, NB, cms, Fus sel C563cms
1981	142027	590715	PL 23	CS 25:375	C37	MM, CT, VY, NB, DM, Erw, SS, rr
1982	188581	590757	PL 24	CS 25:376	C46	MM, CT, VY, NB, DM, Erw, PM, SS, Rr, C17x(C17xC64)
1982	142006	610318			C566aa	mm, CT, Fus, NB, Aa, SF, O-type, see C566
1985	206270	512298	PL 25	CS 28:581	C309	mm, CT, VY,LIY, Erw, DM, Aa, SF, O-type, Rr
1985	206271	512299	PL 26	CS 28:581	C309cms	mm, CT, VY, LIY, Erw, cms, Rr, LIY
1988	220742	590800			C46/2	MM, CT, VY, NB, DM, Erw, PM, SS, Rr
1992	268509	564758	PL 35	CS 34:319-320	C790-15	mm, CT, VY, NB, PM, Aa, SF, O-type, Rr, LIY, *P.betae*
1992					C790-15cms	mm, CT, VY, NB, PM, SF, Rr, LIY, cms of C790-15,*P.betae*
1992	268510	564759	PL 36	CS 34:319-320	C790-54	mm, CT, VY, NB, PM, Aa, SF, O-type, RR
1992	268508	564757	PL 34	CS 34:319-320	C790-6	mm, CT, VY, NB, PM, Aa, SF, O-type, Rr
1994	259742	560130	PL 33	CS 34:319	C762-17	mm, CT, VY, LIY, NB, PM, Aa, SF, O-type, rr
1994					C762-17cms	mm, CT, VY, NB, SF, cms of C762-17
1996		593698	PL 37	CS 38:905	C76-89-5	MM,VY(BChV),NB,Erw,PM,SS,*Rz1*
2001	403113	615522	PL 38	CS 42:321-322	C833-5	mm, Aa, SF, Rz1, O-type, RR, NB, CT
2001	403114	615523	PL 39	CS 42:321-322	C833-5cms	mm, Aa, SF, Rz1, RR, NB, CT, cms of C833-5
Germplasm						
pre-1956				ASSBT 13:555-562	C361	MM, CT, NB, O-type, SS
pre-1956				ASSBT 13:555-562	C361HO,C361cms	MM, CT, NB, cms
pre-1956				ASSBT 13:555-562	C66, C366	MM, CT, NB, Hsugar
pre-1956					C78	not C78 released in 1994
pre-1956					C79	not C79 released in 1994
1954				ASSBT 8:88-89	C3504	MM, CT, NB, DM, SF
1954	98146	590643		ASSBT 11:500-506	NB1, C502	MM, CT, NB, DM, SF, O-type, rr, Hgca
1954	103026	590676			NB1 (S20)	MM, CT, NB, DM, SF, O-type, (selfed 20 generations)
1956	98157			ASSBT 13:555-562	C585, C85	MM, CT, NB,O-type
1956	98158			ASSBT 13:555-562	C585HO, C85cms	MM, CT, NB, cms
1956				ASSBT 13:555-562	C586	MM, CT, NB, SS
1956				SBR 1956:7	C6554M1	MM, CT, NB, Aa, (C366aa x NB4)
1956				SBR 1956:8	C6554M2	MM, CT, NB, DM, Aa, (US75aa x NB4)
1956				ASSBT 13:555-562	C671	MM, CT, NB, SS, O-type
1956				ASSBT 13:555-562	C681M	MM, CT, NB, Aa of C366
1956				SBR 1956:8	C688M	MM, CT, NB, Aa of US75

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1957				ASSBT 13:555-562	C7507	mm, NB, SF, [S_4 from (US22/3 x SLC101mm)]
1957				SBR 1957:8	C7507H1	mm, NB, cms, (F_1 of C7515 X C7507)
1957				SBR 1957:7	C7507HO	mm, NB, cms
1957				ASSBT 13:555-562	C7508	MM, CT, NB, PM, O-type, SF
1957				ASSBT 13:555-562	C7508HO	MM, CT, NB, PM, cms
1957				ASSBT 13:555-562	C7515, C515	mm, CT, NB, O-type, (S5 from NB1 X SLC101mm)
1957				ASSBT 13:555-562	C7515HO	mm, NB, cms
1957				ASSBT 13:555-562	C787	MM, CT, NB, SS
1958	141997				C8503HO	MM, NB, DM, cms
1958				SBR 1958:9	C8507cms rr	mm, NB, cms, (rr of C7507)
1958				SBR 1958:9	C8507rr	mm, NB, (rr of C7507)
1958				ASSBT 13:555-562	C884	MM, LS, NB, SS
1959				ASSBT 13:555-562	C951	MM, NB, O-type from C366
1959				ASSBT 13:555-562	C952	MM, CT, NB, SS, O-type, (from US 15)
1959				ASSBT 13:555-562	C953	MM, O-type from Klein E
1959				SBR 1959:9	C955	mm, CT, NB, SS
1959				ASSBT 13:555-562	C9561, C561	mm, CT, NB, DM, SF, O-type
1959				SBR 1959:9	C9561H1	mm, CT, NB, cms, (F_1 of C7515 X C9561)
1959				ASSBT 13:555-562	C9561HO	mm, CT, NB, cms
1960				SBR 1960:10	C0562H1	mm, CT, NB, cms, (F_1 of 515 x C062)
1960				ASSBT 13:555-562	C663, C63	MM, CT, NB, DM, Hsugar, SS, pollinator of USH6&7,US22xUS15
1960	141995			ASSBT 13:555-562	NB1cms	MM, CT, NB, cms
1960				ASSBT 13:555-562	NB2, C511	MM, CT, NB, DM, SF, O-type
1960	98143	590641		ASSBT 13:555-562	NB3, C509	MM, CT, NB, SF,DM susceptible selection from CT9 for NB
1960	98148	590644		ASSBT 13:555-562	NB4, C554	MM, CT, NB, DM, SF, O-type
1961	142014	590713		SBR 1961:9	C163T, 063T	MM, CT, NB, 4n of C663
1962				ASSBT 13:555-562	C2549	mm, CT, NB, SF
1962				SBR 1962: 8	C2563H1	mm, CT, NB, cms of (569 x C2563)
1962				ASSBT 13:555-562	C264, C64	MM, CT, NB, SS, pollinator of USH7, see C63
1963				ASSBT 13:555-562	C330, C30	MM, VY, SS
1963				SBR 1963:9	C3425T	MM, CT, NB, 4n of (663 x NB7)
1963				ASSBT 13:555-562	C3505	mm, CT, NB, O-type, SF
1963				ASSBT 13:555-562	C3550, C550	mm, CT, NB, O-type, SF
1963				SBR 1963:9	C3550H1	mm, CT, NB, cms, (F1 of 563HO x C3550)
1963				ASSBT 13:555-562	C3550HO	mm, CT, NB, cms
1964				ASSBT 13:555-562	C3534, C534	mm, CT, NB, O-type, SF
1964				ASSBT 13:555-562	C3534H4	mm, CT, NB, cms of (563HO x C3534)
1964				SBR 1964:8	C3539T	MM, CT, NB, 4n of NB7
1964	98149	590645		ASSBT 13:555-562	NB5, C547	MM, CT, NB, DM, SF, O-type
1964	98150	590646		ASSBT 13:555-562	NB7, C539	MM, CT, NB, DM, SF, pollinator of USH8
1965				SBR 1965:7	C4633	mm, CT, NB, O-type
1965				SBR 1965:8	C4742, C742	MM, VY, SF
1965				SRB 1965:7	C5564, C564	mm, CT, NB, O-type
1965	230806	590806		ASSBT 14:75-78	C5600, C600	MM, BB (doubled haploid), CT, NB, O-type C600cms (1988),SF, rr
1966				SBR 1966:7	C534, C03	MM, VY, NB, SS, from Netherlands
1966				SBR 1966:7	C5564HO	mm, CT, NB, cms
1966				SBR 1966:7	C685T	MM, 4n, O-type, SS,CT
1966				SBR 1966:7	C685TH0	MM 4n, cms

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1967	98144	590642		SBR 1967:8	C613, C13	MM, VY, NB, SS,CT, pollinator of USH9
1967				SBR 1967:9	C630T	MM, VY, NB, 4n, SS
1967				SBR 1967:9	C7601	mm, CT, NB, SF
1967				SBR 1967:9	C7760, C760	MM, CT, VY, NB, SF
1967				SBR 1967:9	C786T	MM, NB, Hsugar, 4n, SS,CT, from US22
1968				SBR 1968:A2	C713T	MM, CT, VY, 4n, SS
1968				SBR 1968:A2	C8535	mm, CT, SF
1969	98162	590654		SBR 1969:A1	C813, C17	MM, CT, VY, NB, SS, see parental lines, pollinator of USH10
1971					C565	mm, CT, NB, O-type, SF
1971					C565cms	mm, CT, NB, cms
1976			GP 6	CS 17:677-678	C17T	MM, CT, VY, NB, 4n, SS
1976					C23	MM, CT, NB, Erw, SS, C17 type
1976	98161	590653	GP 5	CS 17:677-678	C321, C21	MM, CT, NB, composite, O-type, SS
1976	98152	590815	GP 7	CS 17:677-678	C522	mm, CT, NB, O-type, SF
1976	98154	590816	GP 8	CS 17:677-678	C522cms	mm, CT, NB, cms
1976			GP 9	CS 17:677-678	C536	mm, CT, NB, O-type, SF
1976			GP 10	CS 17:677-678	C536cms	mm, CT, NB, cms
1976	98156	590817	GP 3	CS 17:677-678	C85	MM, CT, NB, O-type, SS
1976	98157	590818	GP 4	CS 17:677-678	C85cms	MM, CT, NB, cms
1976	103060	590831			Y18, C18	MM, VY, O-type, SS
1976	103061	590832			Y18cms	MM, VY, cms
1976	103063	590833			Y20, C20	MM, VY, O-type, SS
1976	103059	590834			Y20cms	MM, VY, cms
1976	103024	590674			Y45, C45	MM, VY, PM, SS, (from The Netherlands)
1977	103050	590679	GP 20	CS 18:1100-1101	C01	MM, VY, SS, composite of all VY to 1966, see C31
1977	103062	590683	GP 22	CS 18:1100-1101	C04	MM, VY, NB, SS
1977			GP 24	CS 18:1100-1101	C10	MM, VY, NB, O-type, SS
1977	103064	590684	GP 23	CS 18:1100-1101	C22	MM, CT, VY, NB, SS
1977	103065	590685	GP 21	CS 18:1100-1101	C31	MM, VY, NB, Erw, SS
1977			GP 27	CS 18:1100-1101	C705	mm, CT, VY, NB, O-type, SF, RR
1977			GP 28	CS 18:1100-1101	C705cms	mm, CT, VY, NB, cms, RR
1977	103071	590829	GP 29	CS 18:1100-1101	C706	mm, CT, VY, NB, O-type, SF
1977	103052	590830	GP 30	CS 18:1100-1101	C706cms	mm, CT, VY, NB, cms
1977	142021	590849	GP 25	CS 18:1100-1101	C718	mm, CT, NB, O-type, SF, rr, Hgca, source of commercial parents
1977	142022	590850	GP 26	CS 18:1100-1101	C718cms	mm, CT, NB, cms, rr
1977	103070	590688	GP 17	CS 18:1099-1100	C773	MM, CT, VY, NB, Aa, SF, Rr, first *aa* facilitated random mated popn
1977	103069	590835	GP 18	CS 18:1099-1100	C789	mm, CT, VY, NB, Aa, O-type, SF, Rr
1977	103068	590836	GP 19	CS 18:1099-1100	C789cms	mm, CT, VY, NB, cms, Rr
1978	98160	590652			8420	4n, (Janasz from Poland),Hsugar
1978	98159	590651			0834, C534	VY, NB, (from The Netherlands)
1978	103057	590825	GP 76	CS 22:900-901	C16, Y17	MM, VY, O-type, SS, rr
1978	103056	590826	GP 77	CS 22:900-901	C16cms	MM, VY, cms, rr
1978	103045	590827	GP 78	CS 22:900-901	C19, Y19	MM, VY, NB, O-type, SS
1978	103058	590828	GP 79	CS 22:900-901	C19cms	MM, VY, NB, cms
1978	103025	590675	GP 75	CS 22:900-901	C32	MM, VY, BM(*Bm*), SS, Rr
1978	103053	590680	GP 74	CS 22:900-901	C43	MM, CT, VY, NB, Erw, BM(*Bm*), SS, rr
1978	142023	590851	GP 82	CS 22:900-901	C779	mm, CT, VY, NB, PM, O-type, SF, rr
1978	142024	590852	GP 83	CS 22:900-901	C779cms	mm, CT, VY, NB, PM, cms

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1978	103072	610303			0755, C310(C6)	mm, CT, NB, Erw, PM, Aa, LIY, Rr
1978	98158	590650			S303	mm, CT, 4n, SF
1979	103066	590686			740	mm, CT, Aa, O-type, SF, composite
1979	103067	590687			741	mm, CT, Aa. O-type, SF, composite
1979	103028	610301			8563 (S14)	mm, CT, NB, SF (selfed 14 generations),see C563
1979	103031	610302		ASSBT 14:75-78	8600, C5600, C600	MM, BB (doubled haploid), CT, NB, O-type, SF, rr, hard bolting BB
1980	142025				Y905,R&G Pioneer	R&G Pioneer, MM,SS, Open-pollinated variety from Holly storage
1980	142033				Y106,R&G Old Type	R&G Old Type, MM,SS, Open-pollinated variety from Holly storage
1980	141993	590708			US22/3	MM, SS, CT, Open-pollinated variety, CT from US1
1981	142011	590710			039, 39	CT, NB, 4n
1981	141994	633934			043, 43	MM, O-type from Klein E
1981	142008	610319			051, 51	MM, NB, O-type 366, SS, (NB, O-type US35/2)
1981	142009	610320			055, 55	mm, CT, NB, SS
1981	142010	610321			056, 56	mm, SS (American 955 x Russian mm, PI 254575)
1981	142016	608804			0405, 405	MM, CT, NB, 4n, hybrid of (Janasz x NB1)
1981	141998	610313		ASSBT 8:241-246	0533, 533	MM, (susceptible to alternaria leaf spot)
1981	142015	590714			1401	MM, CT, NB, 4n of NB1, O-type
1981	142007				044, C44	VY, hybrid of [330(California) x 234(The Netherlands)]
1981	142012	590711			052T	MM, NB, 4n, O-type, (from US15)
1981	142013	590712			086T	MM, NB, 4n, Hsugar, (from US35/2)
1981	142026	610322			717, C717	MM, CT, VY, NB, DM, BM(*Bm*), SF, rr, (C17Bm)
1981	142034	610324			749-1	mm, VY, Aa, SF, composite
1981	142035	610325			749-2	mm, VY, Aa, SF, composite
1981	142036	610326			749-3	mm, VY. Aa, SF, composite
1981	142037	610327			750-1	mm, VY, Aa, SF, composite
1981	142038	610328			750-2	mm, VY, Aa, SF, composite
1981	142039	610329			750-3	mm, VY, Aa, SF, composite
1981	142040	610330			750-4	mm, VY, Aa, SF, composite
1981	142028	590716	GP 73	CS 22:900-901	C42	MM, CT, VY, NB, Erw, PM, SS, C64x(C13xC03)
1981					C503-S18	MM, NB, DM, SF, (selfed 18 generations)
1981					C512-S15	MM, CT, NB, SF, (selfed 15 generations),see NB6, very high NB
1981					C542	mm, SS, Swiss Chard
1981					C547-S19	MM, CT, NB, O-type, SF, (selfed 19 generations),see NB5
1981	141999	610314		CALIF AGR,18:2-4	1547H0, C547cms	MM, CT, NB, cms, (21st backcross)
1981					C554-S16	MM, Fus, NB, SF, (selfed 16 generations),see NB4
1981	142005	610317			C564aa, 1564AA	mm, CT, NB, Aa, SF,O-type, see C563
1981	142006	610318			C566aa, 1566AA	mm, CT, NB, Fus, Aa, SF,O-type, Fus from C563
1981		590648	see PL3	ASSBT 13:555-562	C7569, C569	mm, CT, NB, O-type, SF, O-type of USH7, 8, & 9A
1981	142029	590853	GP 80	CS 22:900-901	C758	mm, CT, VY, NB, O-type, SF
1981	142030	590854	GP 81	CS 22:900-901	C758cms	mm, CT, VY, NB, cms
1981	141996	590709		ASSBT 13:555-562	C8503-S18, 1503	MM, NB, DM, (inbred of 0503), (selfed 18 generations)
1981	141997	610312			1503H0(14BC)	MM, cms, NB, DM, cms of 1503 14th BC
1981	142002	610315		ASSBT 13:555-562	C8569H0, C569cms	mm, CT, NB, cms of C569
1982	188583	590759			C015, C15	MM, CT, VY, NB, PM, SS, (from US15)
1982	142031	590717	GP 102	CS 27:371-372	C301	mm, Aa, LIY, O-type, SF, RR, CT, parental line
1982	142032	610323		CS 27:371-372	C301cms	mm, LIY, cms, RR,1755-29H0, 1755-29cms
1982					C31/4	MM, VY, NB, Erw, PM, SS, see C31
1982					C41aa	mm, Aa, red flesh, (Detroit Dark Red)

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1982		590676	GP 66	CS 22:698	C502-S25	MM, CT, NB, O-type, SF, rr, (selfed 25 generations),see NB1
1982	142004	610316	GP 67	CS 22:698	C502aa, 1502AA	MM, Aa, SF, see NB1, NB1aa
1982	142003		GP 68	CS 22:698	C512, NB6	MM, CT, NB, DM, SF, (selfed 15 generations),very NB
1982	162335	590723	GP 69	CS 22:698	C554, NB4	MM, CT, NB, Fus, SF, (selfed 16 generations)
1982	188585	590761			C719	MM, CT, VY, NB, PM, BM(*Bm*), Erw, SF, rr, near C17 with SF, Bvm
1983	185474	590751	GP 88	CS 24:830	C35-1	MM, CT, VY, NB, Erw, PM, SS, rr
1983	185475	590752	GP 89	CS 24:830	C35-2	MM, CT, VY, NB, Erw, PM, SS
1983	185476	590753	GP 90	CS 24:830	C40	MM, CT, VY, SS, rr, (Erw susceptible check),segregating for partial ms
1984	188587	590865			743	mm, CT, VY, NB, Erw, Aa, O-type, SF, Rr
1984	188586	590762			747,C747	MM, CT, VY, NB, Erw, Aa, SF of C37,popn-747
1984	188588	590866			0743cms	mm, CT, VY, NB, Erw, cms, Rr
1984	188594	610402			64308PL	MM, RZ(quantitative), from Italy, SS, (Alba LS)
1984	188593	610401			70026PL	MM, RZ(quantitative), from Italy, SS, (Alba LS)
1984	206265	590779	GP 103	CS 27:371-372	C302	mm, CT, Aa, O-type, SF, Rr
1984				CS 27:371-372	C302cms	mm, CT, cms, (note: distributed but NSSL policy was not to store cms)
1984	206266	590780	GP 104	CS 27:371-372	C303	mm, CT, LIY, Aa, RR
1984				CS 27:371-372	C303cms	mm, CT, LIY, cms
1984	206267	590781	GP 105	CS 27:371-372	C304	mm, CT, Aa, O-type, RR
1984				CS 27:371-372	C304cms	mm, CT, cms
1984	206268	590782	GP 106	CS 27:371-372	C305	mm, CT, Aa, Hsugar, O-type, SF, RR
1984				CS 27:371-372	C305cms	mm, CT, Hsugar, cms
1984	188589	590867	GP 107	CS 27:371-372	C306	mm, CT, Aa, LIY, O-type, SF, Rr
1984	188590	590868		CS 27:371-372	C306cms	mm, CT,LIY, cms
1984	188591	590869	GP 108	CS 27:371-372	C307	mm, CT, Aa, O-type, SF, Rr
1984	188592	590870		CS 27:371-372	C307cms	mm, CT, cms
1984	206269	590783	GP 109	CS 27:371-372	C308	mm, LIY, CT, Aa, O-type, SF, RR
1984				CS 27:371-372	C308cms	mm, LIY, CT, cms, RR
1984	188582	590758			C31/5, C031/5	MM, VY, NB, Erw, SS
1984	206276	515964	GP 124	CS 28:873-874	C790	mm, NB, Aa, O-type, mm composite, SF, Rr,Cyc5 S1 recurrent sel
1984	206277	590784	GP 110	CS 27:371-372	C790-2	mm, Aa, O-type, SF, rr
1984	206279	590786	GP 111	CS 27:371-372	C790-41	mm, Aa, O-type, SF, Rr
1984	206280	590787	GP 112	CS 27:371-372	C790-42	mm, Aa, O-type, SF, Rr
1984	206281	590788	GP 113	CS 27:371-372	C790-55	mm, Aa, O-type, SF, Rr
1984	206282	590789	GP 114	CS 27:371-372	C790-65	mm, Aa, O-type, SF, rr
1984	206283	590790	GP 115	CS 27;371-372	C790-68	mm, Aa, O-type, SF, RR
1984	206285	590876		CS 28:873-874	C790cms	mm, NB, mm composite, cms of C790, Rr
1984	206286	515965	GP 125	CS 28:873-874	C796	mm, VY, CT, NB, Aa, O-type, mm x MM composite, SF, rr
1984	206287	590877	GP 118	CS 27:371-372	C796-22	mm, CT, VY, NB, Aa, O-type, SF
1984	206288	590878		CS 27:371-372	C796-22cms	mm, CT, VY, NB, cms
1984	206289			CS 28:873-874	C796cms	mm, VY, CT, NB, cms of C796, rr
1984	188584	590760			Y26	MM, CT, VY, NB, Erw, PM, SS, (from US56/2)
1985	206278	590785	GP 116	CS 27:371-372	C790-25	mm, O-type, SF, rr, inbred from SSD
1985				CS 27:371-372	C790-25cms	mm, cms, rr
1985	206284	590875	GP 117	CS 27:371-372	C790-69	mm, O-type, SF, rr, inbred from SSD
1985				CS 27:371-372	C790-69cms	mm, cms, rr
1985	220747	590804			C91, Y41	MM, CT, VY, NB, Erw, PM, SS, Rr
1985	220748	590805			C92, Y52	MM, CT, VY, NB, Erw, PM, SS, Rr
1985	193633	see610426		ASSBT 11:500-506	NB1 X NB4	MM, CT, NB, cms, F1 cms hybrid, aka cms of NB1 x NB4 standard check

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1986	206272	515962	GP 122	CS 28:873-874	C310 (C5)	mm, CT, NB, Erw, PM, Aa, LIY, SF, Rr,popn-755
1986	206273	610423		CS 28:373-374	C310(C5)cms	mm, CT, Erw, PM, cms
1986	206274	590873		CS 28:373-374	C310(C6)	mm, CT, NB, Erw, PM, Aa, LIY, Rr, cycle 6 sel from popn-755
1986	206275	590874		CS 28:373-374	C310(C6)cms	mm, cms
1986		515963	GP 123	CS 28:873-874	C789/2	mm, CT, VY, NB, Erw, O-type, SF, Aa, Rr
1986	206290	590791			F2 (Y54 x *Bvm*),R22	MM, SS, Bb, composite sugarbeet x *Bvm, Rz?*, see C50, unselected F_2
1986	206295	610426		ASSBT 11:500-506	NB1 X NB4, 554H1	MM, CT, NB, cms F_1cms hybrid used by UC for nutrition research
1988	220738	590797			C11T	MM, NB, Erw, PM, 4n, SS
1988	220739	590798			C12T	MM, NB, Erw, Hsugar, 4n, SS
1988	220740	590799			C31/6	MM, VY, NB, Erw, PM, SS, Rr
1988					C311	mm, CT, NB, Erw, PM, Aa, RZ(*Rz1)*,Holly RZ resistance
1988	220741	583373	GP 150	CS 35:596-597	C39	MM, CT, VY, NB, Erw, PM, RZ(quantitative), SS, Rr
1988	259818	560336	GP 151	CS 35:596-597	C39R	MM, CT, VY, NB, Erw, PM, RZ(quantitative), SS, Rr
1988	259819	560337	GP 152	CS 35:596-597	C39R-6	MM, CT, VY, NB, Erw, PM, RZ(quantitative), SS, Rr, full sib
1988	220742	590800			C46/2	MM, CT, VY, Erw, PM, see C46
1988	251799	538251	GP 140	CS 33:882-883	C48	MM, RZ2 & 3 (from *Bvm*, C37xWB41 & 42), Erw, SS.
1988	220743	590801			C49	MM, CT, VY, NB, Erw, PM, SS, Rr
1988	220744	564243	GP 141	CS 33:882-883	C50, R22	MM, RZ(Rz?) (from *Bvm*), SS, 50% *Bvm* gp
1988	220745	590802			C54	MM, CT, VY, NB, Erw, PM, SS, Rr
1988	230807	520748	GP 129	CS 29:246	C600cms	MM, BB (doubled haploid), CT, NB, cms of C5600 (1965), rr
1988	220746	590803			C70	Mm, VY, RZ(Rz) (from Holly), SF:SS
1988	193633	see610426			NB1 X NB4, 554H1	MM,SF, F_1 cms hybrid, used by UC for iron uptake research
1988	206294	590643		ASSBT 13:555-562	NB1, C502	MM, CT, NB, DM, SF, O- type, rr
1988	206291	590792		ASSBT 13:555-562	NB1cms, C502HO	MM, CT, NB, cms of NB1 and 554H1
1988	206296	590644		ASSBT 13:555-562	NB4, C554	MM, CT, NB, DM, SF, O-type of 554H1
1989	251789	538250	GP 132	CS 31:244-245	C28	MM, RZ(*Rz?*), SS, (from PI 206407, chard like plant),in C37
1989					C313	mm, Aa, PM,LIY, SF
1989	259823	560341	GP 142	CS 33:882-883	C58	MM, VY, Erw, PM, RZ(*Rz?*) (from *Bvm*), SS, Rr
1989					C742-24	mm, Aa, O-type, SF, Rr
1989					C766-23	mm, Aa, O-type, SF, RR
1989					C790-92	mm, SF, rr
1989	259822	560340	GP 156	CS 35:596-597	C94	MM, Rhizoc, RZ(quantitative), SS, Rr, FC & GW gp
1989	259824	560342	GP 153	CS 35:596-597	C47	MM, CT, VY, NB, Erw, PM, SS, Rr
1989	259820	560338	GP 154	CS 35:596-597	C47R	MM, VY, Erw, PM, RZ(quantitative), SS, Rr
1989	259821	560339	GP 155	CS 35:596-597	C93	MM, VY, Erw, PM, SS, Rr
1990	271844	565281			C49/2	MM, CT, VY, NB, Erw, PM, SS
1991	259747	560135	GP 138	CS 32:1297	C31-43	MM, VY, NB, Erw, PM, SS, full-sib
1991	259748	560136	GP 139	CS 32:1297	C31-89	MM, VY(BChV), NB, Erw, PM, SS, full-sib, Hgca
1991	259746	560134			C312	mm, LIY, Aa, SF, Rr
1991	259745	560133			C766-62	mm, CT, VY, NB, Erw, Aa, SF, rr
1991	259744	560132			C767-46	mm, CT, VY, NB, Erw, O-type, SF, rr
1991	259743	560131			C796-43	mm, CT, VY, NB, Erw, Aa, O-type, SF, rr
1992	271848	565285	GP 147	CS 35:289-290	C859	Mm, CT, NB, RZ(*Rz1*),Fus, Aa, O-type, SF, Rr,popn-859
1992					C859cms	Mm, CT, Fus, RZ(Rz1), cms, Rr
1993	271845	565282			C54/2, Y54	MM, CT, VY, NB, Erw, PM, SS
1993	271849	565286			B883	MM, SF, Nema (*Hs1^{pro-1}*) from IRS (Netherlands)
1993	289923	578086			C76-43	MM, VY, NB, Erw, PM, RZ(*Rz1*), SS
1993	289924	578087			C76-89	MM, VY(BChV), NB, Erw, PM, RZ(*Rz1*), SS

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1993	329964	593700			C890	mm, Aa, SF, composite, RZ(*Rz1*) of C790,popn-890
1993	289917	578080			C909-34	MM, CT, NB, Erw, PM, RZ(*Rz1*), SF
1993	289918	578081			C909-37	MM, CT, NB, Erw, PM, RZ(*Rz1*), SF
1993	289920	578083			C911-12	MM, CT, NB, Erw, PM, RZ(*Rz1*), SF
1993	289921	578084			C911-14	MM, CT, NB, Erw, PM, RZ(*Rz1*), SF
1993	289919	578082			C911-4	Mm, CT, NB, Erw, PM, RZ(*Rz1*), SF
1993	289922	578085			C911-50	MM, CT, NB, Erw, PM, RZ(*Rz1*), SF
1993	289916	578079			C918	MM, Aa, VY,CT,SF, composite, RZ(*Rz1*), popn-918,see C931
1994	329902	593671	GP182	CS 37:1037	C78	MM, CT, VY, NB, Erw, PM, RZ(*Rz1*) in C46 background, SS, Rr
1994	329891	593660	GP171	CS 37:1026	C79-1, C79	MM, RZ(*Rz1*) (Holly), SS, (in C37 background)
1994	329900	593669	GP180	CS 37:1026	C79-10	MM, RZ(*Rz?*)(WB 169), SS, (in C37 background)
1994	329901	593670	GP181	CS 37:1026	C79-11	MM, RZ(*Rz?*) (WB 258), SS, (in C37 background)
1994	329892	593661	GP172	CS 37:1026	C79-2	MM, RZ(*Rz3*) (WB 41), SS, (in C37 background)
1994	329893	593662	GP173	CS 37:1026	C79-3	MM, RZ(*Rz2*) (WB 42), SS, (in C37 background)
1994	329894	593663	GP174	CS 37:1026	C79-4	MM, RZ(*Rz?*) (PI 206407), SS, (in C37 background),see C28
1994	329895	593664	GP175	CS 37:1026	C79-5	MM, RZ(*Rz?*) (weed beet), SS, (in C37 background)
1994	329896	593665	GP176	CS 37:1026	C79-6	MM, RZ(*Rz?*) (Italy Sugarbeet), SS, (in C37 background)
1994	329897	593666	GP177	CS 37:1026	C79-7	MM, RZ(Rizor) (SES), SS, (in C37 background)
1994	329898	593667	GP178	CS 37:1026	C79-8	MM, RZ (*Rz1&?*) (Bvm), SS, (in C37 background), Nema?
1994	329899	593668	GP179	CS 37:1026	C79-9	MM, RZ(*Rz?*) (WB 151), SS, (in C37 background)
1994	329903	593672	GP183	CS 37:1037	C80	MM, VY, NB, Erw, RZ(Rz1), SS, Rr
1994	329905	593674			C80-45	MM, VY, NB, Erw, RZ(Rz1), SS, Rr
1994	329904	593673			C80NB	MM, VY, NB, Erw, PM, RZ(*Rz1*), SS, Rr
1994	329906	593675	GP 184	CS 37:1037	C82, R76	MM, VY, NB, Erw, RZ(*Rz1*), SS, Rr, *Rz1* in C31/6 background
1996	329960	593696			C76-43-14	MM, VY, NB, RZ(*Rz1*), SS
1996	329961	593697			C76-43-15	MM, VY, NB, Erw, PM, RZ(*Rz1*), SS
1996	329963	593699			C76-89-18	MM, VY(BChV), NB, Erw, PM, SS, Hgca
1996	329969	593705			C890-6/7	Mm, VY, NB, Erw, PM, SF, RZ(*Rz?*) from Rizor/Italian, Rr, Aa
1996	329972	593708			C890-10/11	Mm, VY, NB, Erw, PM, SS, RZ (*Rz?*) from WB169/258, Rr, Aa
1996	338958	595750	GP195	CS 38:902	C890-7	mm, *Rz?*, SES-Rizor sugarbeet, Aa, SF (in C790 background)
1996	338960	595752	GP199	CS 38:902	C890-11	mm, *Rz?*, WB258, Aa, SF (in C790 background)
1996	329959	593695			C78/2	MM, CT, VY, NB, Erw, PM, RZ(*Rz1*), SS, see C78,C78/3
1996	329965	593701	GP190	CS 38:902-903	C890-1	mm, RZ(*Rz1*), Aa, O-type, SF, (in C790 background)
1996	338959	595751	GP198	CS 38:902-903	C890-10	mm, RZ(*Rz?*) (WB 169), Aa, SF, (in C790 background)
1996	329966	593702	GP191	CS 38:902-903	C890-2/3	mm, RZ(*Rz2 & 3*) (WB 41/WB 42), Aa, SF, (in C790),*P.betae*
1996	329967	593703	GP192	CS 38:902-903	C890-4	mm, RZ(*Rz?*) (PI 206407), Aa, SF, (in C790 background)
1996	329968	593704	GP193	CS 38:902-903	C890-5	mm, RZ(*Rz?*) (weed beet), Aa, SF, (in C790 background)
1996	338957	595749	GP194	CS 38:902-903	C890-6	mm, RZ(*Rz?*) (Italy sugarbeet), Aa, SF, (in C790 background)
1996	329970	593706	GP196	CS 38:902-903	C890-8	mm, RZ(*Rz1 & ?*)(R22,C50) (*Bvm*), Aa, SF, (in C790 background)
1996	329971	593707	GP197	CS 38:902-903	C890-9	mm, RZ (*Rz?*) (WB 151), Aa, SF, (in C790 background)
1996	329955	593691	GP189	CS 38:903	C913-70	MM, *Rz1*, Aa, Sf, VY, rr, NB, Erw
1996	329956	593692			CR09	MM, LS, *Rz1*, Aa, SF, Rr, C931 x Italian gp
1996	329957	593693			CR10	MM, LS, *Rz1*, Aa, SF, Rr, C931 x Italian gp
1996	329958	593694	GP214	CS 40:1513-1515	C51	MM, *Rz1,Rz?*, SS, 50% *Bvm*, Nema, Rr, VY, see C50 & R22
1997	355476	599341	GP209	CS 40:1511	C69	MM, *Rz1*, SS, VY, NB, Erw, PM, composite VY gp
1997	355475	599340			C67	MM, *Rz1, Rz?*, VY, SS, *Bvm* (C50) (10%), Nema
1997	355477	599342			C72	MM, *Rz1, Rz?*, VY, SS, *Bvm* (C50) (5%), Nema
1997	355478	599343			CZ25	MM, *Rz1*, Aa, SF, Hsugar, (37% Polish),popn-Z25

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1997	355858	599349			N499	MM, SS,BB, *Bvm*, Nema, accession from Germany
1997	355859	599350			R423	MM, SS, RZ, composite *Bvm*, PI 518000s (100% *Bvm* gp)
1997	355860	599351			R423B	MM, SS,RZ, composite *Bvm*, PI 518408-540610 (100% *Bvm* gp)
1997	355861	599352			R720	MM, SS,RZ, composite *Bvm* from France, UK (100% *Bvm* gp)
1998					C829-3	mm, Aa, SF, *Rz1*, VY, O-type, Rr,(note: distributed, not stored)
1998					C831-3	mm, Aa, SF, *Rz1*, VY, O-type, RR, CT,(distributed, not stored)
1998					C831-4	mm, Aa, SF, Rz1, VY, O-type, rr, CT,(distributed, not stored)
1998					C833-12	mm, Aa, SF, Rz1, O-type, RR, NB, CT,(distributed, not stored)
1998					C859-8	mm, Aa, SF, *Rz1*, O-type, rr ,(distributed, not stored)
1998					C864-14	mm, Aa, SF, *Rz1*, O-type, Rr, CT, (distributed, not stored)
1998					C867-1	mm, Aa, SF, *Rz1*, O-type, Rr, CT, (distributed, not stored)
1998					C890-10mm	mm, Aa, Sf, *Rz1*, O-type, rr (distributed, not stored)
1998					C911-4-7	mm, *Rz1*, non O-type, Rr, VY, Hsugar, (distributed, not stored)
1999		610490	GP210	CS 40:1515	CP01	MM, SS, PM (Pm), *Bvm* WB97, VY, CT, C37 background
1999		610491	GP211	CS 40:1515	CP02	MM, SS, PM (Pm), *Bvm* WB242, Nema, VY, CT, C37 background
1999		610488	GP212	CS 40:1513-1515	C26	MM, SS, sugarbeet x *Bvm*, RZ, VY, 50% *Bvm* gp
1999		610489	GP213	CS 40:1513-1515	C27	MM, SS, sugarbeet x *Bvm*, RZ, VY, 50% *Bvm* gp
2001	403111	615520	GP219	CS 42:320-321	CZ25-9	MM, Aa, SF, *Rz1*, RR, Hsugar (50% Polish)
2001	403112	615521	GP220	CS 42:672-673	CR09-1	MM, Aa, SF, *Rz1*, RR, LS (25% Italian)
2001	403115	615524			C911-4-10	mm, SF, *Rz1*, RR, non-O-type, NB, Erw, VY, Hsugar
2002	412846	628750	GP229	CS 44:358-359	C67/2	MM, Rz1, *Rz?*, VY, SS, Bvm (10%), Nema
2002	412847	628751	GP230	CS 44:358-359	C69/2	MM, *Rz1*, VY, SS, Erw, PM
2002	412848	628752	GP231	CS 44:358-359	C78/3	MM, *Rz1*, VY, SS, Erw, PM, NB, CT, reselection of C78/2&C78
2002	412849	628753	GP232	CS 44:358-359	C80/2	MM, *Rz1*, VY, SS, Erw, PM, NB, CT
2002	412850	628754	GP226	CS 44:357-358	C869, EL-C869	mm, SF, Aa, *Rz1*, CT, O-type, Rr, mm composite,popn-869
2002	412851	628755	GP227	CS 44:357-358	C869cms,EL-C869CMS	mm, SF, Aa, *Rz1*, CT, CMS, Rr
2002	412852	628756	GP233	CS 44:359-361	C927-4	MM, *Rz1, Rz?*, SF, Aa, VY, Rr, Nema, 12% *Bvm*, segregating Fus
2002	412853	628757	GP234	CS 44:359-361	C929-62	MM, *Rz1*, SF, Aa, VY, PM, NB, CT, RR
2002	412854	628758	GP235	CS 44:359-361	C930-19	MM, *Rz1*, SF, Aa, VY, CT, NB, Erw, PM, Rr
2002	412855	628759	GP236	CS 44:359-361	C930-35	MM, *Rz1*, SF, Aa, VY, CT, NB, Erw, rr, Hsugar (25% Polish)
2003	422531	632284	GP240	CS 44:1886-1887	CP03	MM, SS, PM (Pm), VY, CT, *Rz1*, C37 background
2003	422532	632285	GP241	CS 44:1886-1887	CP04	MM, SS, PM (Pm), VY, CT, *Rz1*, C37 bkgd, Nema, stay green, *P. betae*
2003	422533	632286	GP242	CS 44:1886-1887	CP05	MM, SS, PM (Pm), VY, CT, *Rz1*, C78 background
2003	422534	632287	GP243	CS 44:1886-1887	CP06	MM, SS, PM (Pm), VY, CT, *Rz1*, C78 background
2003	422535	632288	GP244	CS 44:2276-2277	CP07	MM, SS, PM (Pm), VY, CT, *Rz1*, C78, Nema, seg determinate stalks
2003	422536	632289	GP245	CS 44:2276-2277	CP08	MM, SS, PM (Pm), VY, CT, *Rz1*, C37 background, Nema
2004	427650	634217	GP248	CS 45:2665-2666	C842	mm, SF, Aa, O-type, CT, *Rz1*, Rr, composite mm CT,popn-842
2004	427651	634218	GP249	CS 45:2665-2666	C842cms	mm, SF, Aa, CMS, CT, *Rz1*, Rr
2004	427649	634216		SBR 2003:A36	C81-22	MM, SS, VY(BChV), *Rz1*, Rr, Erw, full sib
2005		636338	GP256	CS 46:1414-1415	CN12	MM, SF, Aa, *Rz1*, VY, PM (Pm), Nema (C931 x WB242), 12% *Bvm*
2005		636339	GP257	CS 46:1414-1415	CN72	MM, Bb, SF, Aa, Rz1, 25% *Bvm*, Nema from N499
2005		636340	GP252	CS 46:1412-1414	C931	MM, SF, Aa, *Rz1*, CT, VY, Erw, base MM-SF-Aa-population-931
2005		636341	GP253	CS 46:1412-1414	C941	MM, SF, Aa, *Rz1*, CT, VY, Erw,popn-941
2005		636343	GP255	CS 46:1412-1414	CR11	MM, SF, Aa, *Rz1*, LS (Italian gp),popn-911, C931x(CR09xCR10)
2005		636342	GP254	CS 46:1412-1414	CZ25/2	MM, SF, Aa, *Rz1*, Hsugar (Polish gp),popn-Z25
2006				SBR 2006:A32	C79-9-2	MM, SS, *Rz?*(WB151), Rr, selection from C79-9 for RB-BNYVV
2006				SBR 2006:A32	C79-9-3	MM, SS, *Rz?*(WB151), Rr, selection from C79-9 for RB-BNYVV
2006				SBR 2006:A32	C79-9-4	MM, SS, Rz?(WB151), Rr, selection from C79-9 for RB-BNYVV

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
2006	436937	640418		SBR 2005:A34	CP09CT	MM, SS, PM (Pm), VY, CT, *Rz1*, 2%*Bvm*, Nema, Rr, NB
2006	436938	640419		SBR 2005:A33	CR11-88	MM, SF, Aa, *Rz1*, LS, Rr, sel from CR11
2006	436939	640420	GP260	JPR 1:167-169	CN927-202	MM, SF, Aa, *Rz1*, RR, VY, Nema 12% *Bvm* (C50),RR, VY, seg Fus
2006	436940	640421	GP261	JPR 1:167-169	CN926-11-3-22	MM, SF, Aa, *Rz1*, rr, Nema 2% Bvm (C50)
2006	436941	640422	GP262	JPR 1:167-169	CN921-306	MM, SF, Aa, *Rz1*, rr, Nema 27% Bvm (C51, C26, C27)
2007				SBR 2007:CD	CR11-88-505	MM, SF, Aa, LS, CT, *Rz1*,sel CR11-88, component of CR11-88
2007				SBR 2007:CD	CR11-88-515	MM, SF, Aa, LS, CT, *Rz1*, sel CR11-88, component of CR11-88
2007				SBR 2007:CD	CR11-88-536	MM, SF, Aa, LS, CT, *Rz1*, sel CR11-88, component of CR11-88
2007				SBR 2007:CD	CR11-88-545	MM, SF, Aa, LS, CT, *Rz1*, sel CR11-88, component of CR11-88
2007				SBR 2007:CD	CN12-742	MM, SF, PM (Pm), Nema (WB242), *Rz1*, Emp/Stay green
2007				SBR 2007:CD	CN12-751	MM, SF, PM(Pm), Nema (WB242), *Rz1*, Emp/Stay green
2007				SBR 2007:CD	CN12-8-407	MM, SF, PM(Pm), Nema (WB242), *Rz1*, Emp/Stay green
2007				SBR 2007:CD	CN72-427	MM, SF, Nema *Bvm* N477 from Germany
2007				SBR 2007:CD	CN926-11-7-61	MM, SF, rr, Nema *Bvm* C50,Rz1
2007				SBR 2007:CD	CN07-410	MM, SS, Nema *Bvm* WB242
2007				SBR 2007:CD	CN07-413	MM, SS, Nema *Bvm* WB242, PM(Pm)
2007				SBR 2007:CD	CN18-438	MM, SS, Nema *Bvm* WB242, PM(Pm)
2007				SBR 2007:CD	CD07,CP07D	MM, SS, PM(Pm), *Bvm* WB242,sel for determinant shoot growth
2008		652891			CR933	MM, SF, Aa, *Rz1*, LS, Aphan, RA, CT, VY, Rr, Salinas x Colorado gp
2008		652892			CR933-14	MM, SF, Aa, *Rz1*, LS, RA, CT, VY, Rr, sel from CR933
2008		652888		SBR 2007:CD	CR11-6	MM, SF, Aa, *Rz1*, LS, Aphan, Rr, sel from popn-CR11
2008		652889		SBR 2007:CD	CR11-7	MM, SF, Aa, LS, *Rz1*, Aphan, rr sel from popn-CR11
2008		652890		SBR 2007:CD	CR951-210	MM, SF, Aa, LS, *Rz1*, VY, rr, Hgca
2008		651522		SBR 2007:CD	C812-41	mm, SF,O-type, RR, Aa, CT, LS, Rz2/ 3 from WB41/42, *Rz2Rz2,P.betae*
2008		651523		SBR 2007:CD	C812-41cms	CMS of C812-41
2010		657939	GP280	JPR 6(2):1-5	CN12-446	MM, SF, PM(Pm), Nema (WB242), *Rz1*, Emp/Stay green
2010		657940	GP281	JPR 6(2):1-5	CN12-770	MM, SF, PM(Pm), Nema (WB242), *Rz1*, Emp/Stay green
2010		657938	GP279	JPR 6(2):1-5	CN72-652	MM, SF, Nema *Bvm* N477 from Germany
2011		663878			C500,1500	see SLC 003, MM, BB, SF, rr, O-type, AA-BM(*Bm*), see Ames15638
2011		663879			C500HO,C500cms	see SLC 003ms,Owen's annual ms tester, CMS of C500
2011		663214		SBR 2006:A31	CY91	MM, SS, Rr, *Rz1*, VY(BChV), PM, Erw
2011		663877		SBR 2006:A33	C890-3-41	See C812-41,selection from C890-3 for RB-BNYVV (*Rz2Rz2*),*P.betae*
2011		663872		SBR 2007:CD	C943	MM, SF, Aa, *Rz1*, Hsugar from Polish gp
2011		663874		SBR 2007:CD	C849	mm, SF, Aa, *Rz1*, CT, Hsugar from Polish gp
2011		663873		SBR 2007:CD	C944	MM, SF, Aa, *Rz1*, CT, VY, Erw, Hsugar from Polish gp,C1Syn1 by S1's
2011		663215		SBR 2007:CD	CY95	MM, SS, *Rz1*, Erw, PM, VY, CT, Composite Salinas VY gp, Nema
2011		663213		SBR 2007:CD	CY77	MM, SS, *Rz1*, Erw, VY, Composite Salinas VY gp with 5% *Bvm*(C50)
2011		663881		SBR 2007:CD	CN926-11-10-91	MM, SF, rr, Nema *Bvm* C50,*Rz1*, very compact flowering/seed set
2011		663880			CD07	determinate stalks, MM, SS, PM(Pm), VY, *Rz1*, Rr, see CP07
2011		663875			C21BM	MM, SS, Rz, VY, bb, Rr, 50% *Bvm*
2011		663876			C23BM	MM, SS, Rz, VY, Rr,100%*Bvm*
2013		669447		SBR 2007:CD	CN921-515	MM, SF, rr, Nema *Bvm* C51,C26,C27
2013		669448		SBR 2007:CD	CN921-516	MM, SF, rr, Nema *Bvm* C51,C26,C27
Nematode Resistant						
1958				ASSBT 13:555-562	C8503	MM, DM, Nema tolerant
1958				SBR 1958:10	C8503HO	MM, DM, Nema tolerant, cms
1963				SBR 1963:9	19	MM, Nema tolerant, (C. Price)

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1963				SBR 1963:9	033-1	MM, Nema tolerant, (C. Price)
1963				SBR 1963:9	060-3	MM, Nema tolerant, (C. Price)
1964				SBR 1964:9	010-7	MM, Nema tolerant, (C. Price)
1964				SBR 1964:9	C057-15	MM, Nema tolerant, (C. Price)
1966				SBR 1966:7	590-1	MM, Nema tolerant, US 41,(C. Price)
1979	103051				5942	Nema, (The Netherlands)
1982	176419		GP 86	CS 23:1021	H770	MM, Nema, Bb, SF (Yu)
1982	206292	610424			N101-3	Nema, (H. Savitsky), N101,N102,N103, *Hs1^{pro1}*
1982	206293	610425			N104-5	mm, Nema, Aa (H. Savitsky), N104,N105, *Hs1^{pro1}*
1982	206311	610427			NR1,2 (B.p.)	Nema, B. *procumbent* type plants, (McFarlane)
1983					NR	Nema, (55465 X 55458)
1983					NR	Nema, (55235 X 55255)
1983	206297	590793			NRN1, NR1	Nema, (H. Savitsky)
1983	206298	590794			NRN2, NR2	Nema, (H. Savitsky)
1983					NRN7	Nema, (55465 X 55458)
1992		565286			B883	MM, Nema, *Hs1^{pro1}*, SF, (homozygous NR from The Netherlands)
1992	289925	578088	GP 159	CS 35:1129-1130	C604	MM, Nema, *Hs1^{pro1}*,SF (B883)
1992					C605	MM, Nema, *Hs1^{pro1}*, SF (B883)
1992					C606	MM, Nema, *Hs1^{pro1}*,SF (B883)
1992					C607	MM, Nema, *Hs1^{pro1}*, SF (B883)
1993	271846	565283	GP 157	CS 35:1129-1130	C603	MM, Nema, *Hs1^{pro1}*, SF (B883)
1993	271847	565284	GP 158	CS 35:1129-1130	C603-1	MM, Nema, *Hs1^{pro1}*, SF (B883)
1994	329907	593676			C608	MM, Aa, Nema, *Hs1^{pro1}*, RZ(*Rz1*), SF, Rr (B883)
1994	329908	593677			C609	MM, Aa, Nema, *Hs1^{pro1}*, RZ(*Rz1*), SF, Rr (B883)
1995		586688	GP166	CS 36:469	M66	MM, RKN, (from WB 66, PI 546387), allele *R6m-1 Meliodogyne* resistant
1995		593237	GP170	CS 37:295	Mi-1	MM, RKN, (from WB258, PI 546426)
2000		613165	GP216	CS 41:278-279	M6-1	MM, RKN (resistant to *Meloidogyne* spp.)
2000		614899	GP218	CS 42:317-318	M1-2	MM, RKN
2001		628749	GP221	CS 42:1756-1757	M1-3	MM, RNR, K403
2002		632234	GP237	CS 44:1502-1503	M6-2	MM, RR, RKN, *Rz1*, K402
2011		663871			M1-4	MM, RKN, *Rz1*, K404, homozygous resistant RKN
2011		663882		SBR 2007:CD	CN24Hs1	MM, SF, Aa, *Rz1*, CT, VY, seg *Hs1^{pro1}*, Nema in C931 background
2011		663884		SBR 2007:CD	CN65-9Hs1	mm, SF, *Rz1*, homozygous *Hs1^{pro1}*, Nema
2011		663885		SBR 2007:CD	CN65-9Hs1 cms	CMS of CN65-9Hs1
2011		663883			CN69Hs1	mm, SF, Aa, *Rz1*, CT, seg *Hs1^{pro1}*, Nema
Savitsky						
1962				SBR 1962:11	S-133	MM, Hsugar from Janasz (Polish), SS
1962				SBR 1962:8	S-201	MM, CT, 4n, vigorous, SS
1962				SBR 1962:9	S-202	MM, CT, 4n, SS
1962				SBR 1962:11	S-203	MM, 4n of S-133, SS
1962				SBR 1962:8	S-23	mm, LS, NB, SF, rr
1962				SBR 1962:9	S-301	mm, CT, NB, 4n, SF
1962				SBR 1962:8	S-71	mm, CT, SS
1963				SBR 1963:10	S-132	MM, LS, 4n, SS
1963				SBR 1963:10	S-204	MM, LS, 4n, SS
1963				SBR 1963:10	S-302	mm, NB, 4n, SF
1964				SBR 1964:9	S-205	MM, LS, 4n, SS

Year Released	NSSL Code	Pl No.	CS#	Citation	Code	Description
1964				SBR 1964:9	S-206	MM, CT, LS, 4n, SS
1965				SBR 1965:9	S-63-11	MM, CT, LS, 4n, SS, 4n mm x US 401
1965				SBR 1965:9	S-63-12	MM, CT, LS, 4n, SS, 4n mm x US 401
1965				SBR 1965:9	S-63-13	MM, CT, LS, 4n, SS, 4n mm x US 401
1965				SBR 1965:9	S-63-9	MM, CT, LS, 4n, SS, 4n mm x US 401
1966				SBR 1966:8	S-4-900	MM, CT, 4n,Hsugar
1966				SBR 1966:9	S-4-903	MM, CT, 4n, Hsugar
1966				SBR 1966:8	S-5-200	MM, CT, 4n
1966				SBR 1966:8	S-5-333	MM, CT, 4n
1966				SBR 1966:8	S-5-800	MM, CT, 4n
1967				SBR 1967:9	S-127	mm, CT, 4n
1967				SBR 1967:10	S-235	MM, CT, 4n, SS
1967				SBR 1967:10	S-240	MM, CT, 4n, SS
1967				SBR 1967:10	S-242	MM, CT, 4n, SS
1967				SBR 1967:10	S-258	MM, CT, 4n, SS
1967				SBR 1967:10	S-560	mm, CT, 4n, SS
1967				SBR 1967:11	S-571	mm, CT, 4n, SS
1967				SBR 1967:11	S-572	mm, CT, 4n, SS
1967				SBR 1967:11	S-582	mm, CT, 4n, SS
1967				SBR 1967:11	S-610	MM, CT, 4n, SS
1967				SBR 1967:11	S-615	MM, CT, 4n, SS
1968				SBR 1968:A2	S-120	mm, 4n, SS
1968				SBR 1968:A2	S-507	MM, Hsugar, 4n, SS
1968				SBR 1968:A3	S-523	MM, CT, 4n, SS
1968				SBR 1968:A3	S-537	mm, LS, 4n
1968				SBR 1968:A3	S-640	MM, CT, 4n, SS
1968				SBR 1968:A3	S-938	MM, 4n, SS
1969				SBR 1969:A2	S-112	MM, CT, 4n, SS
1969				SBR 1969:A2	S-130	mm, CT, 4n, SF
1969				SBR 1969:A3	S-4-513	MM, CT, 4n, SS
1969				SBR 1969:A3	S-4-551	MM, CT, 4n, SS
1969				SBR 1969:A2	S-4-603	MM, CT, 4n, SS
1969				SBR 1969:A2	S-4-614	MM, CT, 4n, SS
1969				SBR 1969:A2	S-5-692-1	MM, Hsugar, SS
1969				SBR 1969:A2	S-5-692-2	MM, 4n, Hsugar, SS
1970				SBR 1970:A3	S-4-903	MM, CT, 4n, SS
1970				SBR 1970:A3	S-4-908	MM, CT, 4n, SS
1970				SBR 1970:A3	S-4-929	MM, 4n, SS
1970				SBR 1970:A2	S-5-3-519	MM, CT, 4n, SS
1970				SBR 1970:A2	S-5-4-563	mm, CT, 4n, SS
1970				SBR 1970:A3	S-5-4-601	MM, CT, 4n, SS
1970				SBR 1970:A3	S-5-4-936	MM, 4n, Hsugar, SS
1970				SBR 1970:A2	S-5-4-971	MM, CT, LS, 4n, SS
1970				SBR 1970:A3	S-5-537-5	mm, LS, 4n
1970				SBR 1970:A2	S-5-692-2	MM, 4n, Hsugar, SS
1971					S-5-4-501	mm, NB, 4n, SS

Sugarbeet breeding, East Lansing, Michigan

The history of sugarbeet variety testing and germplasm development in East Lansing by ARS and Michigan State University is long and rich, and has been recently summarized (Panella et al., 2014). Early research from the late 1890's to the mid 1940's was primarily 'variety' evaluation (typically open-pollinated (OP) varieties from Europe) for agronomic potential and particularly for stand establishment issues, which in large part resulted from damping-off due to *Aphanomyces cochlioides* Drechs., for which resistance was developed (Schneider and Hogaboam, 1983). After WWII, G.J. Hogaboam, a returning B17 pilot, was hired as a Research Agronomist and primarily converted OP varieties to hybrids through development of CMS and O-type maintainers from the Salt Lake City ARS program (Hogaboam, 1957). Hogaboam worked closely with G.E. Coe (ARS geneticist; Beltsville, MD), who was developing pollinator lines with resistance to Aphanomyces black root (also called 'blackleg') and Cercospora leaf spot (CLS caused by *Cercospora beticola* Sacc.) as well as improved sugar yield. Together they released US H20 (PI 631354) (Table 2), perhaps the most important publically-developed Eastern U.S. hybrid.

Hogaboam retired in 1985, and J.C. Theurer (geneticist) was relocated to East Lansing from Logan, UT where he joined J.W. Saunders (geneticist), who was working with tissue culture and regeneration of clonal plants as well as somatic cell selection for herbicide resistance (Saunders, 1982; Saunders et al., 1992). Through 1994 when Theurer retired, his major focus was breeding low soil tare (smooth-root, SR) germplasm (Theurer, 1993). Saunders, until his untimely death in 2000, continued and extended Theurer's work. In 1996, J.M. McGrath was hired as an ARS research geneticist to continue the germplasm enhancement efforts, and he, Saunders, and J.M Halloin (plant pathologist) combined SR with enhanced Cercospora resistance, germplasm enriched for O-type maintainer alleles, and combined resistance to Rhizoctonia crown and root rot (*Rhizoctonia solani* Kühn). This was a project that Hogaboam had initiated in the late 1970's beginning with Fort Collins, CO ARS germplasm. The East Lansing program has continued this germplasm enhancement legacy, through improvement of the sugar content in SR lines culminating in the release of SR96 and SR97, improved Rhizoctonia resistance, with the release of two germplasms, SR98 and SR98/2, and the discovery Rhizoctonia seedling disease resistance. L.E. Hanson joined the East Lansing program as an ARS sugar beet pathologist in 2007, improving understanding of the major disease pressures faced by Michigan growers, primarily fungal pathogens, and beginning a focus on seedling disease occurrence and developing tools for seedling disease resistance breeding.

Other germplasm enhancement activities included development of Aphanomyces resistance using unadapted, crop wild relatives (CWR) such as sea beet (*Beta vulgaris* subspecies *maritima* – *Bvm*) (EL54). Enhanced germination and emergence under salt and other stresses (EL57) also was investigated, as was increased seed storage longevity under suboptimal storage conditions (EL55), which apparently results from an in-

creased sensitivity to abscisic acid leading to protracted dormancy (Waxmonsky and McGrath, unpublished). More recently, introgression of resistance to sugarbeet cyst nematode (*Heterodera schachtii* Schm.) from USDA-ARS Salinas-selected germplasm from R.T. Lewellen and K. Richardson resulted in release of EL60 (and others awaiting release, Table 2) with good agronomic performance under Michigan SBCN infestation. Conventional population improvement approaches are being augmented by an increased focus on genetics and genomics of characters and traits important for growers and processors.

Beginning in 1998, East Lansing initiated populations that represent 'breeding for genetic analyses' with the goal of understanding the genes and genetics underlying agronomic and disease resistance traits and the genes that define crop use types within *Beta vulgaris*. A self-fertile, genetic male sterile recipient with good agronomic characters and no known resistances to predominant pathogen pressures in the Eastern U.S. (i.e., C869 from the ARS program in Salinas, CA, and its derivatives) was used as a common seed parent and a series of hybrids were created between East Lansing germplasm releases and other pollinators, and hundreds of these hybrids have been self-pollinated to give F_2 seed. Derivatives of these populations have been released as improved germplasm including TBEL1, an elongated very sweet red beet being developed for the table processing industry. EL54 is an off-shoot of a mapping population with WB 879 (PI 540625) with a novel source of Aphanomyces resistance. Its hybrid, however, was marked by total male sterility and thus inappropriate for creating a mapping population. To date, five populations have been advanced to the F_6 as recombinant inbred lines (RILs) (MSR: C869 x red table beet; AYA: C869 x WB 879 F_3::F_6; SxR: 7S self-fertile inbred sugarbeet x self-fertile red beet; CRB: C869 x EL50 Cercospora resistant; and RTA: C869 x EL51 Rhizoctonia resistant). Fodder beet, Swiss chard, and high and low sugar populations are in earlier stages of development (e.g. <F_5 of inbreeding). These inbred lines, populated with molecular markers prior to their eventual formal release, will be screened across years and environments to build robust and predictive genetic models of phenotypic characters contributing to agronomic profitability.

Populations and phenotypes are the key to germplasm improvement, however environmental effects often occlude phenotypes making selection inefficient. For this reason, molecular markers are essential to provide context and clarity. Ideally the responsible genes will need to be fully characterized, and the era of next-generation nucleotide sequencing provides an almost inevitable potential to characterize all the genes of sugarbeet. Although still in its infancy, eventually this technology will change growers' thought processes from considering a variety choice to a choice of the ideal genetic packages needed for their particular farming operations. Geneticists at many of the locations are involved in this genome reconstruction *in silico*, and to date preliminary genome sequences have been obtained for releases FC607 (Brucoleri, Panella, Smigocki, McGrath, unpublished), KDH13 (Eujayl, 2012, NCBI accession

SRX347469), C869 (Townsend and McGrath, unpublished), and KWS2320 (http://bvseq.molgen.mpg.de/index.shtml). Much activity will be centered on gene and genome level analyses over the next 10 years.

Sugarbeet breeding, Fargo, North Dakota

Prior to 1969 there were no USDA-ARS sugarbeet research projects in North Dakota or Minnesota, states that harvested 105,057 hectares, 16% of the U.S. acreage, in 1969 (http://quickstats.nass.usda.gov/). This changed in 1969 when W.M. Bugbee, a pathologist, and R.M. Cressman, a physiologist, were assigned the task of establishing a USDA research program that would benefit the region's expanding industry. D.F. Cole, also a physiologist, replaced Cressman in 1972. Bugbee and Cole focused much of their attention on postharvest storage losses, primarily storage rots and the respiration rate of stored roots (Campbell, 2005a). They developed and adapted methods to screen for respiration rate and resistance to storage rots and began selecting for resistance and reduced respiration rate. This effort culminated in the release of two germplasm lines, F1001 and F1002 (Table 2), with resistance to *Phoma betae* (Oud.) Frank, *Botrytis cinerea* Pers., and *Penicillium claviforme* Bainer, and a line with a reduced postharvest respiration rate, F1003.

Breeding for improved postharvest storage traits received increased attention with the addition of a geneticist, L.G. Campbell, to the research unit in 1978. With strong support from the beet sugar industry in Minnesota and North Dakota, six germplasm lines, F1004 to F1009, were released from this program between 1982 and 1988. Since 1985, development of lines with storage rot resistance or low postharvest respiration rates (Campbell and Seiler, 1994) has been deemphasized.

The lack of genetic diversity among commercial sugarbeet lines may increase the vulnerability of the crop to widespread disease epidemics and could impede future improvement (Frese et al., 2001). Attempts to enhance the genetic diversity of sugarbeet germplasm began at Fargo in 1980 with selection among and within 167 biennial *B. vulgaris* subspecies vulgaris accessions from the USDA-ARS National Plant Germplasm System's (NPGS) *Beta* collection (Campbell, 1989). This effort resulted in the release of five lines, F1010 to F1014, with sucrose concentrations similar to those measured in commercial hybrids at the time. Efforts to introduce exotic germplasm into cultivated sugarbeet expanded after the transfer of D.L. Doney from the sugarbeet research unit at Logan, UT to Fargo in 1982 (Doney, 1993; Biancardi et al., 2012). Four lines; y317, y318, y322, and y387; Doney selected from sugarbeet crossed with *Bvm* source populations, were released in 1994. Doney continued to hybridize cultivated lines and wild *Beta* spp. populations until his retirement in 1996. Early-generation selection in the populations that became F1017 to F1023 was under Doney's supervision and approximately 30 populations currently in the Fargo breeding program were formed prior to his retirement. Selection from crosses of L19 with three of the lines released by Doney in 1994 culminated with the release of three germplasm lines (F1030, F1031, and F1032) with enhanced sucrose concentrations.

During his tenure at Fargo, Doney led several wild *Beta* collecting expeditions, which have increased the diversity within the USDA-ARS NPGS *Beta* collection substantially. He also had a leadership role in the establishment and initial success of the Sugarbeet Germplasm Committee (originally the Sugarbeet Crop Advisory Committee). Under the guidance of this committee, *Beta* germplasm evaluation and collection oversight became a model for other crops (Doney, 1995a).

Selection for soluble non-sucrose constituents of the root, impurity components, (Campbell, 2002) that interfere with sugar extraction (sodium, potassium, and amino-N) and are sometimes used to calculate payments to growers (Hilde et al., 1983) was initiated at Fargo by G.A. Smith when he transferred to Fargo from Ft. Collins, CO in 1988 and has continued since his retirement in 1998. Additional selection in a previously selected population from Fort Collins (Smith and Martin, 1989) culminated in the release of F1025, F1026, and F1027 with reduced sodium, potassium, and amino-nitrogen concentrations, respectively, in 2011. Two genetic stocks selected for low (F1028) and high (F1029) amino-nitrogen concentration from a broad based population, F1010, were released in 2013 (Campbell and Fugate, 2013). The objective of this research was to provide insight into the extent these impurities can be reduced without having negative effects on root yield and sucrose concentration and the interactions among the individual components that may complicate processing quality improvement.

The encouragement and assistance of A.W. Anderson, an Entomologist with North Dakota State University, was invaluable in the establishment of a sugarbeet root maggot (*Tetanops myopaeformis* von Röder) resistance breeding program in 1983 (Campbell, 2005b; Campbell et al., 2008). All selection for resistance and root maggot damage evaluations rely on natural infestations in the northern Red River Valley at sites near St. Thomas, ND. The first root maggot resistant germplasm line, F1015, was released in 1996. Since then two lines with improved resistance have been released, F1016 and F1024. Current objectives include searching for additional unique sources of resistance and developing populations that combine root maggot resistance with resistance to prevalent diseases and increased sucrose concentration. F1024, released in 2009, combines a high level of root maggot resistance with moderate resistance to CLS and selection within populations with the potential to introduce resistance to other diseases continues. The conventional breeding methods being employed in the root maggot resistance program at Fargo have been complemented by research into the mechanisms and control of resistance with the collaboration of A.C. Smigocki, USDA-ARS Beltsville, MD (Smigocki et al., 2008).

Sugarbeet research currently being conducted by USDA-ARS at Fargo is concentrated in three areas, physiology (K.K. Fugate), pathology (M.D. Bolton), and breeding and genetics (L.G. Campbell). The three projects are housed in the Northern Crop Science Laboratory, which is part of the Red River Valley Agricultural Research Center. Cooperative projects with the Plant Sciences, Plant Pathology, and Entomology De-

partments at North Dakota State University are common. Frequent communication with growers, sugar cooperative staff, private industry representatives, and personnel associated with other publicly funded organizations keep the research focused on finding solutions to the industry's problems.

Sugarbeet breeding, Fort Collins, Colorado

In 1926 Colorado had a greater acreage of sugarbeet than any other state, and, economically, it was the most important farm crop, "the mortgage maker" (Panella et al., 2014). Production was not without problems, including periodic epidemics of CLS or "the blight". USDA stationed a plant pathologist, D. Stewart, in Fort Collins to work CLS located as a faculty affiliate in the Department of Botany and Plant Pathology at Colorado State University (CSU).

By 1965, when R.J. Hecker (geneticist and plant breeder) joined the USDA-ARS Sugar Beet Research Unit (SBRU), working with G.W. Maag (plant biochemist), G.A. Smith (geneticist and plant breeder), E.G. Ruppel (plant pathologist), S.S. Martin (plant physiologist), and E.E. Schweizer (weed scientist), the research had grown to include development of germplasms with resistance to Rhizoctonia crown and root rot, beet curly top (caused by *Beet curly top virus*), and storage rots. Hecker and Gaskill's early releases, FC701 and FC702 (Table 2), provided the source of resistance in many Rhizoctonia-resistant cultivars in use today (Panella and Ruppel, 1996; Panella, 2005). The CLS resistance breeding program was expanded when G.A. Smith joined the SBRU. He included breeding for resistance to beet curly top combined with CLS-resistance, resulting in the release of the FC600 series of germplasm (Panella, 1998; Panella and McGrath, 2010). A graduate student working with Tsuchiya and Hecker, Ignacio Romagosa, produced a trisomic series in sugarbeet for the first time (Romagosa et al., 1986; Romagosa et al., 1987).

R.J. Hecker retired in 1992 and L. Panella joined the SBRU as geneticist. He was joined in 2000 by L.E. Hanson after the retirement of E.G. Ruppel. Germplasms that had been initiated by Hecker were finished, including many that had resistance to Rhizoctonia crown and root rot and CLS (FC709-2, FC715, FC715CMS, FC710 4X, and FC712 4X, etc.). Because rhizomania (caused by *Beet necrotic yellow vein virus*) was an emerging disease in Colorado in the early 1990s, Panella crossed FC germplasms with material from R.T. Lewellen with USDA-ARS at Salinas to incorporate the rhizomania resistance (as well as yellowing virus and curly top resistance) into the Fort Collins germplasm background. Releases from this joint effort include FC201, FC301, FC220, FC221, FC1018, FC1019, FC1020, FC1022, FC1028, FC1036, FC1037, FC10389, FC1740, and FC1741). Together with McGrath and Hanson, Panella and Lewellen released the Cercospora and rhizomania resistant germplasms, FC1028, FC1036, FC1037, and FC1038. With L.G. Campbell at Fargo and A.C. Smigocki at Beltsville, F1024 with resistance to CLS and sugarbeet root maggot was released.

In the 1990s, the needs of the sugarbeet seed companies began to

change and the program at Fort Collins responded by going directly to CWR, especially sea beet, the wild progenitor of sugarbeet, as sources of novel resistance genes (Panella and Lewellen, 2007; Richards et al., 2004; Richards et al., 2013). The current program is focused on discovering novel sources of resistance, often from CWR, and incorporating it into a sugarbeet genetic background and releasing it to industry breeders in a less "agronomically finished" population than in the past. For example, different sources of resistance to CLS were identified in both annual and biennial sea beet and fodder beet. These sources have been crossed into sugarbeet germplasm and gone through a series of field screenings and progeny selection for leaf spot resistance (Panella and Lewellen, 2007). These populations are in the stages of final testing and have begun to be released with FC305 (PI 671963).

Another outgrowth of the collaboration with R. T. Lewellen has been the development additional sources of resistance to the sugarbeet cyst nematode (SBCN) found in sea beet (Panella and Lewellen, 2007). In the transition after Lewellen retired in 2008, Panella used the screening nursery at Brawley, CA, to continue development of germplasms resistant to SBCN, and has continued to work with K. Richardson, R.T. Lewellen's replacement, and the staff at Salinas to screen new sources of resistance. This collaboration continues at both ARS stations and has grown to include collaboration with the Italian group at the University of Padua. A Research project including the University of Padua and both ARS stations has discovered a SNP marker for SBCN resistance (Stevanato et al., 2014b), which allows the research programs to use marker assisted selection (MAS). In addition to using MAS for SCBN, SNP markers linked to both *Rz1* and *Rz2* genes for rhizomania resistance have been used (Stevanato et al., 2012).

The program at Fort Collins does SBCN field screening and selection in Colorado, while the Salinas program continues to screen at Brawley and in the greenhouse. A number of potential new sources of resistance have been discovered in CWR and other domesticated beet types and are being crossed to sugarbeet parents for further selection and testing. Because the SBCN nematode resistance is conferred by a single gene (Stevanato et al., 2014b), there is a concern that it will be overcome, similar to what has happened with the single gene resistance (*Rz1*) to rhizomania, therefore there is a strong interest in finding other genes or alleles that confer resistance to SBCN (Williamson and Kumar, 2006; Liu et al., 2005).

In the course of the GENRES CT95 42 European project (entitled '*Beta*: evaluation and enhancement of *Beta* collections for extensification of agricultural production'), 329 and 368 *Beta* accessions were screened for resistance to Rhizoctonia crown and root rot in the field and greenhouse, respectively (Luterbacher et al., 2005). Additionally, there have been 783 accessions of the USDA-ARS NPGS *Beta* collection screened in the field for resistance to Rhizoctonia crown and root rot (GRIN, 2012). Seven accessions that were judged resistant were crossed in 2011 to sugarbeet germplasm and are being increased in the greenhouse to provide

sufficient seed for testing and selection under field conditions. The current source of resistance continues to be durable in the field but it is complex, difficult to move into new hybrids, and caries a yield penalty. Additionally, there is concern that it may be overcome, and having an alternative source of resistance in development would allow a rapid deployment, if necessary. There also is the potential that another source of resistance could provide transgressive segregation for resistance (Allard, 1960, p. 472), potentially increasing the protection to the crop.

A major emphasis of the research mission in Fort Collins has been the collection, documentation, characterization, evaluation, and utilization of plant germplasm, especially accessions in the USDA-ARS NPGS. The SBRU has coordinated the effort of the Sugarbeet Crop Germplasm Committee's national evaluation program for accessions in the *Beta* collection (Panella and Lewellen, 2007). Because the ARS scientists who evaluate the germplasm are the same researchers who are responsible for the public breeding effort in sugarbeet, the germplasm that is evaluated as resistant is immediately incorporated in pre-breeding efforts. The breeding program at Fort Collins remains focused on discovering novel disease resistance and incorporating it into sugarbeet germplasm for release to private breeders in the U.S. and worldwide.

Sugarbeet breeding, Kimberly, Idaho

The USDA-ARS at the urging of the Idaho sugarbeet growers through the Beet Sugar Development Foundation (Denver, Colorado) established a sugarbeet breeding and pathology research program in 2004 in the ARS station at the Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho. The first scientists recruited to the program were C.A. Strausbaugh (Research Plant Pathologist) and A.M. Gillen (Research Geneticist). The research objectives were focused on development of germplasm with enhanced disease resistance to beet curly top and other important sugarbeet diseases, good agronomic quality, and improved disease management options. The breeding program integrates modern molecular genetics tools with conventional breeding methods. The research program has identified novel sources of beet curly top, rhizomania, Rhizoctonia crown and root rot resistance, and postharvest performance, which will be incorporated into germplasm releases.

Novel sources of resistance to beet curly top were identified in 14 CWR accessions of *Beta corolliflora* (Gillen et al., 2008). Furthermore, molecular analysis established that 9 of these accessions did not carry detectable *Beet curly top virus*. The high level of resistance in these accessions had not been used previously in breeding programs (Gillen et al., 2008), and may provide a model system, in which to better understand the resistance to this disease in cultivated beet. Currently, the pathology component of the program uses highly reliable disease screening methods adapted from other sugar beet programs for establishing nurseries for selection for resistance to beet curly top, rhizomania resistance, Rhizoctonia crown and root rot, and postharvest performance (Eujayl and Strausbaugh, 2012; 2014; Mumford, 1974; Pierson and Gaskill,

1961; Ruppel et al., 1979; Strausbaugh et al., 2009). DNA fingerprinting is used routinely for screening and selection for curly top resistance.

In 2007, I.A. Eujayl replaced Gillen and breeding efforts were refocused on developing mapping populations and breeding lines, which would be suitable for molecular genetics research including linkage mapping, association mapping, and gene expression profiling (Simko et al., 2012). Mapping populations and doubled haploid lines using ovule culture have been developed to allow genetic mapping of curly top and other important traits. This effort has resulted in developing curly top resistant, doubled haploid lines, for studying curly top inheritance and possibly other traits, such as drought tolerance. Germplasm populations K039, and KC944-19 were developed through mass selection and full-sib selection for resistance to curly top and rhizomania. Additionally, large mutant populations (M1) were generated using either ethyl methanesulfonate or Gamma irradiation to broaden the genetic base of the germplasm. This program established a public genome sequencing project using a publicly-available doubled haploid line, KDH13, which has been whole genome sequenced (Eujayl and Strausbaugh unpublished) and a draft assembly (BvvSeq-1) has been deposited in GenBank; (http://www.ncbi.nlm.nih.gov/genome/221?genome_assembly_id=28570). This provided an opportunity for all laboratories to use the same genotype to improve the current assembly (BvvSeq-1) and facilitate further downstream research. Sequencing of two genomic libraries (mate-pair and paired-end) yielded 82.9 GB raw sequence that achieved 68 fold genome coverage. The draft assembly of 421.43 Mb as well as 54.9 GB sequence reads archive (SRA) were deposited and released at the National Center for Biotechnology Information (NCBI) website. The first outcome of the BvvSeq-1 comparison to other genome assembly was identification of 16,000 single nucleotide polymorphic markers (SNPs) http://www.ars.usda.gov/sp2UserFiles/person/40864/SNP-NWISRL-USDA-Kimberly.xlsx. This program has developed over two thousand diversity array technology (DArT) markers for sugarbeet that are publically available and which were used to develop the first curly top genetic linkage map (Eujayl et al., 2011) and large set of EST-SSRs http://www.ars.usda.gov/sp2UserFiles/person/40864/EST-SSR-perfect_repeats.xls, http://www.ars.usda.gov/ sp2UserFiles/person/40864/EST-SSR-imperfect_repeats.xls, http://www.ars.usda.gov/sp2UserFiles/person/40864/ EST-SSR-perfect_and_imperfect.xls. The general program goal is the introgression of novel sources of disease and pest resistance into sugarbeet germplasm utilizing conventional and markers assisted selection.

Sugarbeet breeding, Salinas, California

R. T. Lewellen was an ARS-USDA Research Geneticist at Salinas, CA from 1966 to 2008. His principal research involved population improvement and germplasm enhancement. Until 1980, he worked closely with J.S. McFarlane and I.O. Skoyen providing a continuum in sugarbeet research from geneticists and breeders at Salt Lake City, UT and Riverside, CA. During this period, the Salinas germplasm was based upon the curly

top resistant material descended from US1 through US22 to US75; and US15 and US15 x US1 to US56 and C663 (Table 2). Cytoplasmic male sterility (CMS) used at Salinas was extracted from male-sterile plants in US56. Self-fertile lines were strongly based on curly top resistant developments at Salt Lake City. Non-bolting selection NB1 and the male sterile of NB1 and SLC101mm were used to develop the C562, C563, C564, C566 series and monogerm, O-type parental lines C569, C546, and C718. Emphasis was placed on breeding parental lines or near parental lines that possessed good general combining ability for sugar yield with resistance to beet curly top and downy mildew, caused by *Peronospora farinosa* f.sp. *betae*, and that had high non-bolting tendency to accommodate the needs of the Far West and winter plantings. Commercial varieties that were developed included open-pollinated US75, multigerm hybrids USH2 through USH6, and monogerm hybrids USH7 and USH8. These hybrids, followed by USH9, USH10, and USH11 and their commercial near equivalents, were widely grown in the western USA.

With the severe occurrence of virus yellows caused by *Beet yellows virus*, *Beet western yellows virus*, and *Beet chlorosis virus*, the Salinas breeding program was expanded to include resistance breeding to virus yellows. Important breeding and parental lines C13, C17, C36, and C37; C01 and C31, C46, C76-43, C76-89, C76-89-5, C76-89-18, and C81-22; and others were developed and released. These were the basis of the virus yellows resistance in hybrids USH9, USH10, USH11, and many named varieties from the sugar and seed company breeders. After the eruption of Erwinia root rot (caused by *Pectobacterium betavasculorum*), powdery mildew (*Erysiphe polygoni*), and lettuce infectious yellows (*Lettuce Infectious Yellows Virus* vectored by the sweet potato whitefly, *Bemisia tabaci*), breeding for resistance to these diseases was added to the program. Resistance to virus yellows remained an important component of the overall population improvement and enhancement program. As other breeding objectives and use of *Bvm* were added, germplasm from the virus yellows resistance program was used as the recurrent parent and consolidated into a number of broadly based germplasms that were released and distributed as C54, C67/2, C69/2, C78/3, C80/2, CY91, CY95, and CY77.

Population improvement was used to 1) develop new open-pollinated varieties and breeding lines, 2) provide superior populations from which to extract new inbred lines, and 3) construct, introduce, and maintain a superior pool of germplasm. The populations were improved by recurrent selection procedures including mass selection and progeny line evaluation and recombination. However, population improvement within the self-fertile material was difficult because recombination after selection could not be controlled. Starting in 1968 at Salinas, populations were developed that combined both self-fertility and genetic male sterility as was being done in sorghum (Doggett populations) (Doggett and Eberhart, 1968), barley (Suneson, 1956), soybean (Brim and Stuber, 1973), and other self-compatible crops, (Bosemark, 1971; Doney and Theurer, 1978; Lewellen and Skoyen, 1987; Panella and Lewellen, 2005). Self-fertile,

genetic male sterile facilitated, random mating populations were developed for both the female (monogerm, O-type) and male (multigerm) sides of sugarbeet hybrid cultivars so that all types of progeny evaluation and recurrent selection could be practiced. The use of S_1 progeny evaluation and recurrent selection was commonly used at Salinas (Lewellen, 1994). All of the breeding objectives were encompassed into these populations. After 10 to 40 years of development, on the female side populations such as C310, C789, C859, C769, C790, C890, C869, C842, and C849 were released and distributed. On the male side, populations such as C747, C773, C918, C931, C941, C943, C944, CR11, CR933, CZ25, CN12, and CN72 were released and distributed. In addition, individual lines and families from specific progeny evaluations were selected and released to provide genetic variability to specific traits, for example, to powdery mildew, rhizomania, and sugarbeet cyst nematode (Grimmer et al., 2007; Grimmer et al., 2008; Scholten and Lange, 2000).

After the early 1980s, a shift, which reflected the changing philosophy of ARS-USDA and the sugarbeet industry in the objectives for public sugarbeet breeding, was made at Salinas that moved the breeding program away from development of finished parental lines and hybrid cultivars to germplasm enhancement and the use of broadly based genetic resources (Lewellen, 1992; Lewellen, 2000; Panella and Lewellen, 2007; Biancardi et al., 2012). The use of all genetic resources was then incorporated into the programs at Salinas. Genetic resources included everything from very highly bred, high sugar germplasm devoid of disease resistance to the CWR, especially *Bvm*. Disease resistant germplasm developed at other ARS and European stations which possessed resistance to Rhizoctonia crown and root rot, Aphanomyces root rot, and CLS was included and collaborative research and breeding were done (e.g., EL0204, FC220, FC221, FC1028, FC1036, FC1037, and FC1038). Much success was achieved by the evaluation and incorporation of germplasm from Bvm. New genes for resistance to rhizomania, sugarbeet cyst nematode, root knot nematode, powdery mildew, etc., were identified (Panella and Lewellen, 2007; Biancardi et al., 2012). Germplasm or breeding lines were developed, released, and distributed that had one or various combinations of these resistances and resistant factors (Panella et al., 2014). (Also see releases from Fort Collins and East Lansing, Table 2). These releases also were important as genetic resources from which to develop molecular markers (Francis et al., 1998; Friesen et al., 2006; Gidner et al., 2005; Scholten and Lange, 2000; Grimmer et al., 2007; Grimmer et al., 2008; Yu et al., 2001; Stevanato et al., 2012; Stevanato et al., 2014a; Stevanato et al., 2014b). Noteworthy among the Salinas releases that contained different degrees of germplasm from *Bvm* were C48, C50, C51, C58, C67/2, C72, C26, C27, CP01, CP02, CP04, CP06, CP07, CP08, CP09CT, CN12, CN72, C21Bm, and C23Bm.

Resistances to specific diseases and pests were targeted. From the program of M.H. Yu, resistance to root knot nematode (*Meloidogyn*e spp.) was found in two *Bvm* accessions and transferred to sugarbeet. The most advanced of these lines were released as M1-3 and M6-2. Resistance to

powdery mildew was identified in *Bvm* lines WB97 (PI 546394) and WB242 (PI 546413) and transferred to sugarbeet. The most advanced populations were released as CP07, CP08, and CP09CT.

Resistance to rhizomania conditioned by *Rz1* was originally found in sugarbeet by Erichsen (Lewellen, 1988; Lewellen et al., 1987). The resistance factor *Rz1* was incorporated into almost all breeding populations and lines in the Salinas breeding programs. Recurrent phenotypic selection for rhizomania resistance concentrated high additive and quantitative resistance that was very effective at protection but was halved and inadequate when used with susceptible parental lines to produce commercial hybrids (Lewellen and Biancardi, 1990). Lines C39, C39/2, C39R-6, C47R, and C94 are the best examples of these from Salinas. Before the *Rz1* gene was known to be compromised by resistance breaking strains of BNYVV, much of the available sugarbeet and cultivated beet germplasm was searched for additional major genes for resistance. Resistance in one plant, which looked like chard from a sugarbeet accession (PI 206407) from Turkey, showed resistance, and after crossing to sugarbeet was released as C28. Otherwise no additional resistance was found in cultivated beets. However many accessions from *Bvm* proved to have resistance genes (Whitney, 1989; Lewellen, 1995; Biancardi et al., 2002; Panella and Lewellen, 2007; Pavli et al., 2011; Biancardi et al., 2012). These resistances were backcrossed into sugarbeet largely without knowing if the resistance factor was the same or different from *Rz1* (Lewellen, 1995; Lewellen, 1997). These backcross derived lines were released in many different germplasm, but the best examples were C48, C58, and the C79 series of releases (C79-2 through C79-11). From these releases, *Rz2*, *Rz3*, *Rz4*, and *Rz5* were reported (Pavli et al., 2011). Broadly based selections for rhizomania resistance from *Bvm* were composited and released as C26, C27, C21Bm, and C23Bm. From the C48 source of resistance, monogerm, O-type lines were ultimately released as C812-41 and C812-41CMS that had resistance to all known strains of BNYVV and possibly to *Polymyxa betae*, the vector of BNYVV (Liu & Lewellen, personal communication; Biancardi et al., 2012). Rhizomania resistance in C812-41 has been shown to be *Rz2Rz2* (unpublished data). The resistance to *P. betae* may have come from monogerm populations C790, C890-2/3 or parental line C790-15 used as the monogerm recurrent sources.

Resistance to sugarbeet cyst nematode (SBCN) (*Heterodera schachtii*) had been an ongoing breeding objective at Salinas for many years. Most of the research and effort was to transfer near immunity from *B. procumbens* (now *Patellifolia procumbens*) to sugarbeet. Savitsky (1975), McFarlane (1982), Yu (2005), and Lewellen (e.g., C603, CN24Hs1, CN69Hs1) all worked to breed true-breeding, nematode resistant breeding lines with the *Hs1*^{pro1} factor (Cai et al., 1997) (Table 2). Although partially successful, genetically stable resistance without significant yield drag was never fully achieved (Biancardi et al., 2012).

Tolerance or partial resistance to SBCN from *Bvm* was known from research in the Netherlands (Heijbroek et al., 1977; Heijbroek, 1977; Lange and de Bock, 1994; Biancardi et al., 2012). Because resistance

from *B. procumbens* and other hard seeded CWR offered the promise of near immunity to *H. schachtii* and the partial resistance from *Bvm* was considered inadequate and still allowed nematode reproduction, it was not fully investigated or exploited (Heijbroek, 1977). Lewellen observed in some populations developed from crosses between sugarbeet and *Bvm* for resistance to rhizomania and powdery mildew that when field tested under severe nematode conditions in the Imperial Valley and at Salinas, there appeared to be useful SBCN resistance with reduced cyst reproduction (Lewellen and Pakish, 2005). This resistance appeared to have dominant gene action and to be inherited fairly simply. In companion tests under severe nematode and non-nematode conditions in the Imperial Valley, this resistance gave moderately high levels of protection against sugar yield losses (Lewellen and Pakish, 2005; Biancardi et al., 2012). Partial resistance was found in several different populations and extractions from these populations that had germplasm partially derived from *Bvm*. These included C51 (aka population R22) and lines such as C927-4 and CN927-202 extracted from it; CP02, CP04, CP06, and CP08; and CN12 and lines extracted from these. The line that contributed SBCN resistance to C51 is not known but could be WB242, one of its components. WB242 is known to be the source of the SBCN resistance as well as the powdery mildew resistance of CP08 and CN12 populations (Biancardi et al., 2012). Resistance to SBCN was also found in other populations (CN72) and lines (CN926-11-3-22, CN921-306) and the relationship to the resistance from WB242 has not been determined. A review of the SBCN resistance program at Salinas is given in the book, *Beta maritima: The Origin of Beets* (Biancardi et al., 2012). The WB242 SBCN resistance was shown to be inherited as a single gene on chromosome 5 called *HsBvm-1* (Stevanato et al., 2014b).

In 2008, R.T. Lewellen retired after 41 of service as the sugarbeet geneticist in Salinas. K. Richardson was selected to fill the position and joined ARS in September 2008. Objectives of Richardson's research are to continue development and release of germplasm, to identify and utilize desirable traits from CWR, and to combine molecular tools and conventional breeding methods to improve germplasm. The pathogens currently of most concern to California sugarbeet growers are rhizomania and sugarbeet cyst nematode. Dr. Richardson's work focuses on these two pests. She has released some of the SBCN resistant germplasm begun by Lewellen, which included registration of CN12-446, CN12-770, and CN72-652 and deposit into the NCGRP of CN921-515 and CN921-516.

Reference List

Allard, R.W. 1960. *Principles of Plant Breeding.* John Wiley and Sons Inc., Hoboken, NJ, USA.

Biancardi, E., R.T. Lewellen, M. de Biaggi, A.W. Erichsen, and P. Stevanato. 2002. The origin of rhizomania resistance in sugar beet. Euphytica 127:383-397.

Biancardi, E., L.W. Panella, and R.T. Lewellen. 2012. *Beta maritima, the Origin of Beets.* Springer Science+Business Media, LLC, New York, NY.

Bosemark, N.O. 1971. Eucarpia Fodder Crops Section, Report of Meeting, at Lusigan, France.

Brim, C.A., and C.W. Stuber. 1973. Application of genetic male sterility to recurrent selection schemes in soybeans. Crop Sci. 13:528-530.

Cai, D., M. Kleine, S. Kifle, H.J. Harloff, N.N. Sandal, K.A. Marcker, R.M. Klein-Lankhorst, E.M.J. Salentijn, W. Lange, W.J. Stiekema, U. Wyss, F.M.W. Grundler, and C. Jung. 1997. Positional cloning of a gene for nematode resistance in sugar beet. Science 275:832-834.

Campbell, L.G. 1989. *Beta vulgaris* NC-7 collection as a source of high sucrose germplasm. J. Sugar Beet Res. 26:1-9.

Campbell, L.G. 2005a. Postharvest storage traits. p. 122-126. *In* E. Biancardi, L.G. Campbell, G.N. Skaracis, and M. de Biaggi (ed.) *Genetics and Breeding of Sugar Beet.* Science Publishers, Inc., Enfield (NH), USA.

Campbell, L.G. 2005b. Sugarbeet root maggot. p. 113-114. *In* E. Biancardi, L.G. Campbell, G.N. Skaracis, and M. de Biaggi (ed.) *Genetics and Breeding of Sugar Beet.* Science Publishers, Inc., Enfield (NH), USA.

Campbell, L.G., and K.K. Fugate. 2013. Divergent selection for amino-ntrogen concentration in sugarbeet roots. J. Sugar Beet Res. 50:1-13.

Campbell, L.G., J. Miller, M. Rekoske, and L.J. Smith. 2008. Performance of sugar beet hybrids with sugar beet root maggot-resistant pollinators. Plant Breed. 127:43-48.

Campbell, L.G., and G.J. Seiler. 1994. Internal CO_2 concentration as a selection criterion for storage respiration rate in sugarbeet. Plant Breed. 112:96-101.

Campbell, L.G. 2002. Sugar beet quality improvement. J. Crop Prod. 5:395-413.

Doggett, H., and S.A. Eberhart. 1968. Recurrent selection in sorghum. Crop Sci. 8:199-121.

Doney, D.L. 1993. Broadening the genetic base of sugarbeet. J. Sugar Beet Res. 30:209-220.

Doney, D.L. 1995a. International activities in Beta germplasm. p. 193-191. *In* R.R. Duncan (ed.) *International Germplasm Transfer: Past and Present.* CSSA Spec. Publ. 23. CSSA, Madison, WI.

Doney, D.L. 1995b. USDA-ARS sugarbeet releases. J. Sugar Beet Res. 32:229-257.

Doney, D.L., and J.C. Theurer. 1978. Reciprocal recurrent selection in sugarbeet. Field Crops Res. 1:173-181.

Eujayl, I., C.A. Strausbaugh, W. Michelke, and A .Kilian. 2011. DArT based genetic linkage map of sugarbeet and mapping of beet curly top. Proc. Am. Soc. Sugar Beet Technol. http://assbt-proceedings.org/ASSBT2011Proceedings/SecBandE.htm .

Eujayl, I. A., Strausbaugh C.A. 2012. Sugar beet germplasm evaluated for resistance to rhizomania and fungal growth in storage in Idaho, 2011. *Plant Disease Management Reports.* Report No.6:FC087

Eujayl, I. and Strausbaugh, C.A. 2014. *Beet curly top resistance in USDA-ARS Kimberly sugar beet germplasm, 2013.* Plant Disease Management Reports. 8:FC250.

Francis, S.A., M. Redfearn, D.M. Chwarszczynska, M.J.C. Asher, and R.T. Lewellen. 1998. Use of molecular markers in breeding for disease resistance in sugar beet (*Beta vulgaris* L.). Aspects App. Biol. 52:279-285.

Frese, L., B. Desprez, and D. Ziegler. 2001. Potential of genetic resources and breeding strategies for base-broadening in *Beta*. p. 295-309. *In* H.D. Cooper, C. Spillane, and T. Hodgkin (ed.) *Broadening the Genetic Base of Crop Production.* FAO, IBPRGI jointly with CABI Publishing, Rome, Italy.

Friesen, T.L., J.J. Weiland, M.L. Aasheim, S. Hunger, D.C. Borchardt, and R.T. Lewellen. 2006. Identification of a SCAR marker associated with *Bm*, the beet mosaic virus resistance gene, on chromosome 1 of sugar beet. Plant Breed. 125:167-172.

Gidner, S., B.L. Lennefors, N.O. Nilsson, J. Bensefelt, E. Johansson, U. Gyllenspetz, and T. Kraft. 2005. QTL mapping of BNYVV resistance from the WB41 source in sugar beet. Genome 48:279-285.

Gillen, A.M., C.A. Strausbaugh, and K.V. Tindall. 2008. Evaluation of *Beta corolliflora* for resistance to curly top in Idaho. J. Sugar Beet Res. 45:99-118.

Grimmer, M., K. Bean, and M. Asher. 2007. Mapping of five resistance genes to sugar-beet powdery mildew using AFLP and anchored SNP markers. Theor. Appl. Genet. 115:67-75.

Grimmer, M.K., T. Kraft, S.A. Francis, and M.J.C. Asher. 2008. QTL mapping of BNYVV resistance from the WB258 source in sugar beet. Plant Breed. 127:650-652.

GRIN. Descriptor Report with frequency of observations. USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN). [Online Database] National Germplasm Resources Laboratory, Beltsville, Maryland. Available: http://www.ars-grin.gov/cgi-bin/npgs/html/crop.pl?49 (17 May 2012). 5-17-2012.

Heijbroek, W. 1977. Partial resistance of sugarbeet to beet cyst eelworm (*Heterodera schachtii* Schm.). Euphytica 26:257-262.

Heijbroek, W., J.S. McFarlane, and D.L. Doney. 1977. Breeding for tolerance to beet-cyst eelworm *Heterodera schachtii* Schm. in sugarbeet. Euphytica 26:557-564.

Hilde, D.J., S. Bass, R.W. Levos, and R.L. Ellingson. 1983. Grower practices system promotes beet quality improvement in the Red River Valley. J. Am. Soc Sugar Beet Technol. 22: 73-88.

Hogaboam, G.J. 1957. Factors influencing phenotypic expression of cytoplasmic male sterility in the sugar beet (*Beta vulgaris* L.). J. Am. Soc. Sugar Beet Technol. 9:457-465.

Lange, W., and T.S.M. de Bock. 1994. Pre-breeding for nematode resistance in beet. J. Sugar Beet Res. 31:13-26.

Lewellen, R.T. 1988. Selection for resistance to rhizomania in sugar beet. p. 455. Proceedings of the 5th International Congress Plant Pathology. Kyoto, Japan.

Lewellen, R.T. 1992. Use of plant introductions to improve populations and hybrids of sugarbeet. p. 117-135. *Use of Plant Introductions in Cultivar Development, Part 2*. Crop Science Society of America, Madison, WI (USA).

Lewellen, R.T. 1994. Registration of C762-17, a parental line of sugarbeet. Crop Sci. 34:319.

Lewellen, R.T. 1995. Performance of near-isolines of sugarbeet with resistance to rhizomania from different sources. p. 83-92. Proceeding of the 58th IIRB Congress. International Institute for Beet Research. IIRB, Brussels, Belgium.

Lewellen, R.T. 1997. Registration of 11 sugarbeet germplasm C79 lines with resistance to rhizomania. Crop Sci. 37:1026.

Lewellen, R.T. 2000. Registration of rhizomania resistant sugarbeet × *Beta vulgaris* subsp. *maritima* germplasms C26, C27, and C51. Crop Sci. 40:1513-1515.

Lewellen, R.T., and E. Biancardi. 1990. Breeding and performance of rhizomania resistant sugar beet. Proceedings of the 53rd Congress of the IIRB 53:69-87.

Lewellen, R. T. and Pakish, L. M. 2005. Performance of sugarbeet cyst nematode resistant cultivars and a search for sources of resistance. J. Sugar Beet Res. 42:48.

Lewellen, R.T., and I.O. Skoyen. 1987. Registration of 17 monogerm, self-fertile germplasm lines of sugarbeet derived from three random-mating populations. Crop Sci. 27:1229-1230.

Lewellen, R.T., I.O. Skoyen, and A.W. Erichsen. 1987. Proc. Proceedings of the 50th Winter Congress of the IIRB. International Institute for Beet Research, Brussels, Belgium.

Liu, H.-Y., J.L. Sears, and R.T. Lewellen. 2005. Occurrence of resistance-breaking *Beet necrotic yellow vein virus* of sugar beet. Plant Dis. 89:464-468.

Luterbacher, M.C., M.J.C. Asher, W. Beyer, G. Mandolino, O.E. Scholten, L. Frese, E. Biancardi, P. Stevanato, W. Mechelke, and O. Slyvchenko. 2005. Sources of resistance to diseases of sugar beet in related *Beta* germplasm: II. Soil-borne diseases. Euphytica 141:49-63.

McFarlane, J.S., H. Savitsky, and A. Steele. 1982. Breeding for resistance to the sugarbeet nematode. J. Am. Soc. Sugar Beet Technol. 21:311-323.

Mumford, D.L. 1974. Procedure for inducing curly top epidemics in field plots. J. Am. Soc. Sugar Beet Technol. 18:20-23.

Panella, L. 1998. Screening and utilizing *Beta* genetic resources with resistance to *Rhizoctonia* root rot and *Cercospora* leaf spot in a sugar beet breeding program. p. 62-72. In L. Frese, L. Panella, H.M. Srivastava, and W. Lange (ed.) *Int. Beta Genetic Resources Network. A report on the 4th Int. Beta Genetic Resources Workshop and World Beta Network Conf.* held at the Aegean Agric. Res. Inst., Izmir, Turkey, 28 February - 3 March, 1996. International Crop Network Series No. 12. International Plant Genetic Resources Institute, Rome.

Panella, L. 2005. Root rots. p. 95-99. In E. Biancardi, L.G. Campbell, G.N. Skaracis, and M. de Biaggi (ed.) *Genetics and Breeding of Sugar Beet.* Science Publishers, Inc., Enfield (NH), USA.

Panella, L., S.R. Kaffka, R.T. Lewellen, J.M. McGrath, M.S. Metzger, and C.A. Strausbaugh. 2014. Sugarbeet. p. 357-396. *In* S. Smith, B. Diers, J.E. Specht, and B.F. Carver (ed.) *Yield Gains in Major U.S. Field Crops.* CSSA Special Publication 33. ASA, CSSA, and SSSA, Madison, WI.

Panella, L., and R.T. Lewellen. 2005. Registration of FC201, a heterogeneous, disease-resistant, monogerm, O-type sugarbeet population. Crop Sci. 45:1169-1170.

Panella, L., and R.T. Lewellen. 2007. Broadening the genetic base of sugar beet: introgression from wild relatives. Euphytica 154:382-400.

Panella, L., and J.M. McGrath. 2010. The history of public breeding for resistance to Cercospora leaf spot in North America. p. 141-156. *In* R.T. Lartey, J.J. Weiland, L. Panella, P.W. Crous, and C.E. Windels (ed.) *Cercospora Leaf Spot of Sugar Beet and Related Species.* APS Press, St. Paul, MN, US.

Panella, L., and E.G. Ruppel. 1996. Availability of germplasm for resistance against *Rhizoctonia* spp. p. 515-527. In B. Sneh, S. Jabaji-Hare, S. Neate, and G. Dijst (ed.) *Rhizoctonia Species: Taxonomy, Molecular biology, Ecology, Pathology and Disease Control.* Kluwer Academic Publishers, Dordrecht.

Pavli, O.I., P. Stevanato, E. Biancardi, and G.N. Skaracis. 2011. Achievements and prospects in breeding for rhizomania resistance in sugar beet. Field Crops Res. 122:165-172.

Pierson, V.G., and J.O. Gaskill. 1961. Artificial exposure of sugar beets to *Rhizoctonia solani.* J. Am. Soc. Sugar Beet Technol. 11:574-590.

Richards, C., P. Reeves, A. Fenwick, and L. Panella. 2013. Genetic structure and gene flow in *Beta vulgaris* subspecies *maritima* along the Atlantic coast of France. Genet. Resour. Crop Evol. 61:651-662.

Richards, C. M., M. Brownson, S. E. Mitchell, S. Kresovich, and L. Panella. Polymorphic microsatellite markers for inferring diversity in wild and domesticated sugar beet (*Beta vulgaris*). Mol. Ecol. Notes, 4:243-245. 2004.

Romagosa, I., L. Cistue, T. Tsuchiya, J.M. Lasa, and R.J. Hecker. 1987. Primary Trisomics in Sugarbeet. II. Cytological Identification. Crop Sci. 27:435-439.

Romagosa, I., R.J. Hecker, T. Tsuchiya, and J.M. Lasa. 1986. Primary trisomics in sugarbeet. I. isolation and morphological characterization. Crop Sci. 26:243-249.

Ruppel, E.G., C.L. Schneider, R.J. Hecker, and G.J. Hogaboam. 1979. Creating epiphytotics of *Rhizoctonia* root rot and evaluating for resistance to *Rhizoctonia solani* in sugarbeet field plots. Plant Dis. Rep. 63:518-522.

Saunders, J.W. 1982. A flexible in vitro shoot culture propagation system for sugarbeet that includes rapid floral induction of ramets. Crop Sci. 22:1102-1105.

Saunders, J.W., G. Acquaah, K.A. Renner, and W.P. Doley. 1992. Monogenic dominant sulfonylurea resistance in sugarbeet from somatic cell selection. Crop Sci. 32:1357-1360.

Savitsky, H. 1975. Hybridization between *Beta vulgaris* and *B. procumbens* and transmission of nematode (*Heterodera schachtii*) resistance to sugar beet. Can. J. Genet. Cytol. 17:197-209.

Schneider, C.L., and G.J. Hogaboam. 1983. Evaluation of sugarbeet breeding lines in greenhouse tests for resistance to *Aphanomyces cochlioides*. J. Am. Soc. Sugar Beet Technol. 22:101-107.

Scholten, O.E., and W. Lange. 2000. Breeding for resistance to rhizomania in sugar beet: A review. Euphytica 112:219-231.

Simko, I., I. Eujayl, and T.J.L. van Hintum. 2012. Empirical evaluation of DArT, SNP, and SSR marker-systems for genotyping, clustering, and assigning sugar beet hybrid varieties into populations. Plant Sci. 184:54-62.

Smigocki, A.C., L. Campbell, R. Larson, and C. Wozniak. 2008. Sugarbeet. p. 59-95. *In* C. Kole, and T.C. Hall (ed.) *Compendium of Transgenic Crop Plants: Transgenic Sugar, Tuber, and Fiber Crops.* Blackwell Publishing Ltd., Oxford.

Smith, G.A., and S.S. Martin. 1989. Effects of selection for sugarbeet purity components on quality and sucrose extractions. Crop Sci. 29:294-298.

Stevanato, P., C. Broccanello, F. Biscarini, M. Del Corvo, G. Sablok, L. Panella, A. Stella, and G. Concheri. 2014a. High-Throughput RAD-SNP Genotyping for Characterization of Sugar Beet Genotypes. Plant Mol. Biol. Rep. 32:691-696.

Stevanato, P., D. Trebbi, P. Norouzi, C. Broccanello, and M. Saccomani. 2012. Identification of SNP markers linked to the *Rz1* gene in sugar beet. Int. Sugar J. 114:715-718.

Stevanato, P., D. Trebbi, L. Panella, K. Richardson, C. Broccanello, L. Pakish, A. Fenwick, and M. Saccomani. 2014b. Identification and validation of a SNP marker linked to the gene *HsBvm-1* for nematode resistance in sugar beet. Plant Mol. Biol. Rep. 1-6.

Strausbaugh, C.A., I. Eujayl, E. Rearick, P. Foote, and D. Elison. 2009. Sugar beet cultivar evaluation for storability and rhizomania resistance. Plant Dis. 93:632-638.

Suneson, C.A. 1956. An evolutionary plant breeding method. Agron. J. 48:188-191.

Theurer, J.C. 1993. Pre-breeding to change sugarbeet root architecture. J. Sugar Beet Res. 30:221-240.

Whitney, E.D. 1989. *Beta maritima* as a source of powdery mildew resistance in sugarbeet. Plant Dis. 73:487-489.

Williamson, V.M., and A. Kumar. 2006. Nematode resistance in plants: the battle underground. Trends in Genetics 22:396-403.

Yu, M.H. 2005. Cyst nematode. p. 103-109. *In* E. Biancardi, L.G. Campbell, G.N. Skaracis, and M. de Biaggi (ed.) *Genetics and Breeding of Sugar Beet.* Science Publishers, Inc., Enfield (NH), USA.

Yu, M.H., L.M. Pakish, and H. Zhou. 2001. An isozyme marker for resistance to root-knot nematode in sugarbeet. Crop Sci. 41:1051-1053.