

Beet curly top resistance in germplasm from the USDA-ARS Ft. Collins program, 2014.

Ninety-seven sugar beet (*Beta vulgaris* L.) germplasm lines from the USDA-ARS Ft. Collins sugar beet program, a resistant control germplasm (1996A008), and three commercial control cultivars [SV2012RR (susceptible), Monohikari (susceptible) and HM PM90 (resistant)] were screened for response to *Beet curly top virus* (BCTV). The Monohikari and HM PM90 controls were included twice. The curly top evaluation was conducted at the USDA-ARS North Farm in Kimberly, ID which has Portneuf silt loam soil and had been in barley in 2013. The field was plowed in the fall and in the spring, it was fertilized (90 lb N and 110 lb P₂O₅/A), sprayed with Ethotron (2 pt/A) for weed control, and roller harrowed on 11 Apr. The germplasm was planted (density of 142,560 seeds/A) on 19 May. The plots were two rows 10 ft long with 22-in row spacing and arranged in a randomized complete block design with four replications. The fields were sprinkler irrigated and hand weeded as necessary. Plant populations were thinned to about 47,500 plants/A on 14 Jun. Plants were inoculated at the four- to six-leaf growth stage on 23 Jun with approximately six viruliferous beet leafhoppers per plant. Strain specific DNA testing from leaf samples in neighboring plots inoculated from the same leafhopper population suggests that all three BCTV strains (Cal/Logan, Severe [formerly CFH], and Worland) were present. The beet leafhoppers were redistributed three times a day during the first two days and then twice a day for five more days by dragging a tarp through the field. The plants were sprayed with Lorsban 4E (1.5 pints/A) on 7 Jul to kill the beet leafhoppers. Plots were rated for foliar symptom development on 16 Jul using a scale of 0 to 9 (0 = healthy and 9 = dead), with the scale treated as a continuous variable (Plant Dis. 90:1539-1544). Data were analyzed in SAS using the general linear models procedure (Proc GLM), and Fisher's protected least significant difference (LSD; $\alpha = 0.05$) was used for mean comparisons.

Curly top symptom development was uniform and no other disease problems were evident in the plot area. There was some loss in plant stand and plant vigor on the east side of the field due to drift of glyphosate from a nearby field. Nonetheless, the control plants as well as blind controls within the trial performed as expected. Resistance to curly top is quantitative in sugar beet as is evident from the continuum of responses between the susceptible and resistant controls. The half sib families from population 20121013 are of particular interest. Entry 20121013-01 showed the most severe symptoms of BCTV, while 20121013-12 was the best performing line outside of the resistant checks. In total, four lines (2012A035, 20121013-12, 20131001pfHO, and 20131002pfHO) were not significantly different from the resistant control performance (HM PM90 with DI = 4.09), while six other lines, 20121018HO-174pf, 20121018HO-275pf, 20121013-48, 20121018HO-77ms, 20121013-57, and 20121018HO-169pf, all half sib families from 2012108 and 20121013 did not differ significantly from HM PM90 with a DI of 4.47. The lines will be investigated further to see if they represent novel sources of curly top resistance, and brought forward for release as curly top resistant germplasms. Identifying novel sources of resistance should allow seed companies to improve resistance to BCTV in commercial sugar beet cultivars. These results and germplasm will be accessible to interested parties through the USDA-ARS, NPGS GRIN database (<http://www.ars-grin.gov/npgs/index.html>).

Entry ^z	Description	CT ratings ^y
20121013-01	FC221-1; RhzcR, RhzmR, R ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	8.31 a
20121054	20081001-38PF, -14MS Blk of sel - LSR fodder beet - SucroseMM x PI 535833 (Saturn)	7.94 ab
20121013-04	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	7.75 a-c
Monohikari	Susceptible check.	7.69 a-d
20111028	20091028ms; 20071003H-74 - CLR family (BGRC 45511/SucroseMM) sib line 20111029	7.44 a-e
20111030	20091030PF; Increase 5 highest CLR families 20071004HO-xs; LSRMM w/Fargo	7.44 a-e
20121018HO-136pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	7.41 a-f
20121013-33	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	7.33 a-g
20121013-40	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	7.32 a-g
20101008	(Best FC LSR x Best EL LSR) - mm seedballs Increased	7.25 a-h
20121018HO-137pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	7.25 a-h
20121018HO-273pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	7.22 a-h
Monohikari	Susceptible check	7.19 a-i
20121013-18	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	7.19 a-i
20121018HO-266pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	7.19 a-i
20121013-37	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	7.16 b-j
20121013-53	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	7.01 b-k
SV2012RR	Susceptible check	6.94 b-l
20111029	20091029PF; Blk best families BGRC 45511 x SucroseMM pop 20071003H-2, -19, -67, -78	6.94 b-l

Entry ^z	Description	CT ratings ^y
20121018HO-212pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.94 b-l
20121018HO-225pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.91 b-m
20131012PF	07-FC1015-403 - Combine mod. CR, Rz1, CTR?, etc., with mm, T-O, %S	6.88 b-m
20121013-26	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.88 b-m
20121018HO-211pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.86 b-m
2013A006	C931, 4931, PI 636340	6.82 b-n
20121013-06	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.78 c-o
20121018HO-08ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.78 c-o
20121018HO-175pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.78 c-o
20121038HO-89ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.75 c-p
20121018HO-253pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.75 c-p
20101010	C790-15cms x 05-FC1018 [RZM-CR-% (C931 x FC709-2)F3]	6.72 c-q
20121013-21	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.70 c-q
20111031	20071003H2; LSR {(BGRC 45511) <i>maritima</i> (Greece/annual) x Sucrose} x Z325aa	6.66 c-r
20121013PF	FC221-1; RhzcR, RhzmR, ({4918, 2915aa}/{FC902, FC607, FC709-2})-hs-blk- <u>hs</u>	6.66 c-r
2013A009	N412, CN12, PI 636338	6.66 c-r
20121013-50	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.63 c-s
20121018HO-01ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.63 c-s
20101012	C790-15cms x RZM-CR-% (FC712 x 9931)F3	6.62 c-s
20121013-35	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.57 d-s
2013A008	4933-14, CR933-14, PI 652892	6.56 d-s
20121013-42	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.55 d-s
20121012HO1	C833-H5 CMS x 03-FC1014-22(A,aa) - sel in 6R BC3	6.50 e-s
20121035PF	09-20071011Hmono & 20071011H - B. Inc. [(FC907 x FC709-2) and 9931] - rogue to mm?	6.50 e-s
20131009	LSR sel ½ sib families; LSR <i>B. v. ssp. maritima</i> (PI 540596) (biennial - France) x Sucrose _{MM}	6.50 e-s
20121013-11	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.50 e-s
20121013-30	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.47 e-s
20121013-45	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.47 e-s
20121013-46	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.44 e-s
20121013-52	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.44 e-s
20121018HO-38ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.44 e-s
1997A050	FC607, LSR/CTR, easy bolting, O-type, 2X, mm, self-sterile	6.41 e-s
20121018HO-258pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.41 e-s
20121013-51	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.38 e-t
20121018HO-343pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.37 e-t
20121018HO-80ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.35 e-t
20121018HO-345pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.35 e-t
20121018HO-129pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.34 e-t
20121012HO	03-FC1014-22 (half sib selection within FC201) - sel in 6R	6.31 e-t
20121018HO-24ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.31 e-t
20121018HO-84ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.31 e-t
20121013-03	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.28 f-u
20121013-24	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.26 g-u
20121013-14	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.26 f-u
20121018HO-233pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.26 f-u
2013A007	5933, CR933, PI 652891	6.25 g-u
20121018HO-25ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.23 g-v
20041010HO	FC712/MonoHy A4	6.22 g-v
20121018HO-308pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.20 g-v
20121013-02	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.14 h-v
20121013-44	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.14 h-v
20121018HO-97ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.12 h-v

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20121018HO-292pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.12 h-v
20121018HO-16ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.07 i-w
20121013-32	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.06 i-w
20121013-05	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.03 j-w
20121013-34	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.03 j-w
20121013-09	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	6.00 k-x
20121018HO-117pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.00 k-x
20121018HO-227pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	6.00 k-x
20121018HO-78ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.97 k-x
20061005HO	03-124 FC123 derivative	5.94 k-x
20121013-36	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	5.94 k-x
20121018HO-352pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.94 k-x
20121018HO-271pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.93 k-x
20121057	20081013-07PF thru -47PF Blk 7 fam - F ₃ LSR/RhzcR/LSR selected for RhzcR-hs10A-1775	5.81 l-y
20121018HO-170pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.81 l-y
20121013-41	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	5.80 l-y
20121018HO-119pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.78 m-y
20121018HO-83ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.70 n-y
20121018HO-187pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.66 o-y
20121018HO-174pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.60 q-z
20121018HO-275pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.60 p-z
20121013-48	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	5.58 q-z
20121018HO-77ms	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.53 r-z
20121013-57	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	5.49 s-z
20121018HO-169pf	03-FC1014-22 (hs sel FC201 (C890aa/FC708 & C859/FC708)) - sel in 6R	5.25 t-z
2012A035	R840 (Blk of RR740)	5.16 u-a
20131001pfHO	R1740 Population (Rz1Rz1Rz2Rz2)	5.10 v-a
20131002pfHO	R1741 Population (rz1rz1Rz2Rz2)	4.97 w-a
20121013-12	FC221-1; RhzcR, RhzmR, ({4918, 2915aa} x {FC902, FC607, FC709-2})-hs-blk	4.88 x-a
1996A008	Beta G6040 - Resistant Check	4.70 y-a
HM PM90	Resistant check	4.47 za
HM PM90	Resistant check	4.09 a
Overall mean		6.38
$P > F^x$		<0.0001
LSD		1.15

^z Three entries were commercial check cultivars (bold): SV2012RR (susceptible), Monohikari (susceptible), and HM PM90 (resistant). Monohikari and HM PM90 were each included twice.

^y Curly top ratings = curly top was rated using a scale of 0 to 9 (0 = healthy and 9 = dead), with disease index (DI) treated as a continuous variable.

^x $P > F$ was the probability associated with the F value. Within a column, means followed by the same letter did not differ significantly based on Fisher's protected least significant difference (LSD; $\alpha = 0.05$) value.