SUGAR BEET (*Beta vulgaris*)
    Rhizomania; *Beet necrotic yellow vein virus*
    Storage rot; *Athelia*-like sp., *Botrytis cinerea*,
        and *Penicillium* spp.

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USDA-ARS pre-breeding germplasm evaluated for Rhizomania and storage rot resistance in Idaho, 2021.

Thirty sugar beet (*Beta vulgaris* L.) lines from multiple USDA-ARS pre-breeding programs and five check cultivars were screened for resistance to *Beet necrotic yellow vein virus* (BNYVV), the causal agent of rhizomania, and to storage rot. The rhizomania evaluation was conducted at the USDA-ARS North Farm in Kimberly, ID which has Portneuf silt loam soil and had been in barley in 2020. In the spring the field was plowed and fertilized (120 lb N and 120 lb P_2O_5/A) and roller harrowed on 17 Mar 21. The germplasm was planted (density of 114,048 seeds/A) on 21 Apr. The plots were one row 10-ft long with 22-in. between-row spacing and arranged in a randomized complete block design with 6 replicates. The crop was managed according to standard cultural practices for southern Idaho. The trial relied on endemic field inoculum for rhizomania and storage rot development. The plots were rated for rhizomania foliar symptom (percentage of plants with yellow, stunted, upright leaves) development on 19 Aug. The plants were mechanically topped and hand harvested on 18-19 Oct. At harvest, ten roots per plot were rated for rhizomania symptom development using a scale of 0 to 9 (0 = healthy and 9 = dead; Plant Disease 93:632-638). At harvest, eight roots per plot were also placed in a mesh-onion bag and kept in an indoor commercial storage facility (temperature set point 34°F) in Paul, ID on 19 Oct. On 28 Feb 22, after 132 days in storage, the roots were evaluated for the percentage of root surface area covered by fungal growth or rot. Except for root ratings, data were analyzed in SAS (Ver. 9.4) using the general linear model (Proc GLM) procedure, and Fisher's protected least significant difference ($\alpha = 0.05$) was used for mean comparisons. The root ratings were rank transformed prior to analysis with the mixed linear models (Proc MIXED) procedure, but the non-transformed means have been presented in the table. Mean separation for root ratings was based on a PDIFF comparison with a probability cutoff of 0.05.

Rhizomania symptom development was uniform and other disease problems were not evident in the plot area. The BNYVV susceptible check plots (Check 1 and Red beet) had 100% foliar symptoms and high root disease ratings. Resistant check 3 had 0% foliar symptoms and a low root rating which indicates that resistance based on two genes is holding up. Single gene resistance (Checks 2 and 4) had foliar ratings ranging from 2 to 4% indicating single gene resistance is not completely effective, but the root ratings were still good. Four entries containing only the Rz1 gene, FC1019, FC1028, FC1035, and FC1038 had a level of BNYVV resistance similar to at least one of the resistant checks based on both foliar and root ratings. These same four entries had low storage rot ratings, and an additional 20 entries had storage rot ratings not statistically different than the commercial check. Twenty-four total entries had resistance to fungal rots in storage statistically similar to the commercial checks, but only FC1019, FC1028, FC1035, and FC1038 performed well for all three variables. Some entries may serve as a starting point for identifying additional sources of resistance to BNYVV and storage rots.

Entry[z]	Description	Root rot in storage (%)[y]	RZ foliar rating (% susceptible plants)	RZ root rating[x]
8	FC1036	2 h	8 j-l	23 k
Check 3	BTSSALCHK3 (*Rz1Rz1 Rz2Rz2*) = *Rz1* + *Rz2* resistant check	4 h	0 l	24 k
Check 4	BTSSALCHK4 (*Rz1Rz1*) = *Rz1* resistant check	7 f-h	4 kl	24 jk
Check 2	BTSSALCHK2 (*Rz2Rz2*) = *Rz2* resistant check	4 h	2 l	25 i-k
14	20161004HO1	3 h	35 f-h	25 h-k
7	FC1018	10 e-h	28 h-j	26 h-k
9	FC1037	3 h	28 h-j	27 h-k
4	FC1028	4 h	15 i-l	28 g-j
23	F1024	4 h	38 e-h	29 g-j
10	FC1038	8 f-h	4 kl	30 f-i
6	FC1019	3 h	13 i-l	30 f-i
5	CR933	3 h	38 e-h	31 f-h
1	FC1020	10 e-h	22 h-k	31 e-h
3	FC1022	3 h	14 i-l	33 d-g
30	SR from E Lansing	17 e	100 a	34 d-g
15	C842	7 f-h	57 de	34 d-g
28	F1002	6 gh	95 ab	34 d-f
24	Z325	4 h	50 ef	35 d-f
18	FC220/F1024	3 h	29 g-i	35 c-f
12	C931	14 e-g	5 kl	36 c-e
19	20041010HO	4 h	73 cd	36 cd
2	C869 CMS	4 h	37 f-h	37 cd
17	FC702/7	9 e-h	100 a	37 cd
29	CS 42	16 ef	82 a-c	37 cd
20	FC716	8 e-h	100 a	38 cd
26	EL53	7 f-h	74 cd	39 cd
25	EL54	10 e-h	48 e-g	39 cd
13	C890	4 h	31 f-i	40 bc
11	FC305	40 c	57 de	40 bc
16	FC607	28 d	100 a	43 ab
Check 1	BTSSALCHK1 (*rzrz*) = susceptible sugar beet check	8 e-h	100 a	45 ab
21	F1043	9 e-h	98 a	45 ab
22	FC727	3 h	75 cd	47 ab
27	NSL80221	54 b	77 bc	48 ab
Red beet	Detroit Dark Red (*rzrz*) = susceptible red beet check	70 a	100 a	64 a
P > F[w]		<0.0001	<0.0001	<0.0001
LSD		9	19	Trans

[z] All lines were *Beta vulgaris* subsp. *vulgaris*. Five commercial cultivars were included as checks.

[y] Root rot in storage = the percent of root surface area covered by fungal growth or rot. Fungal growth was dominated by an *Athelia*-like basidiomycete (Mycologia 104:70-78), *Penicillium expansum*, and *Penicillium cellarum*. Trace levels of *Botrytis cinerea* were also present. ND = no data.

[x] Ten roots per plot were evaluated for rhizomania symptoms using a scale of 0-9 (0 = healthy and 9 = dead; Plant Disease 92:581-587). Root rating = a disease severity index value for each plot established using the following formula: [((A)0+(B)1+(C)2+(D)3+(E)4+(F)5+(G)6+(H)7+(I)8+(J)9)/90]100, where A-J are the number of plants in categories 0-9, respectively.

[w] *P* > F was the probability associated with the F value. LSD = Fisher's protected least significant difference value (α = 0.05). Within a column, means followed by the same letter did not differ significantly based on Fisher's protected LSD. Trans = root ratings were rank transformed prior to analysis with the mixed linear models (Proc MIXED) procedure, but the non-transformed means have been presented in the table. Mean separation for root ratings was based on a PDIFF comparison with a probability cutoff of 0.05.