University of California - 2018 Commercial Entry Fusarium Race 4 Screening - SUMMARY (Tulare County Site)

year = 2018 *FINAL 1/29/2019 version*

COMMERCIAL SEED COMPANY ENTRIES, RBTN (Regional Breeder Testing) program entries

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2018 Fusarium Screen - Summary (Tulare Co.) - University of CA - commercial entries and RBTN entries - R.B. Hutmacher

Entry Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid)	Whole Plot Foliar FOV rating		Single Plant Foliar rating		Root Vasc. Stain Rating		Cotyledon Vasc. Stain Rating		Plant height (inches)		Main Stem Node #		Percent Survival	
				mean	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*
BX 1921 GL	*901*	**Tulare**	U	1.33	0.58	0.13	0.52	1.87	1.36	0.93	0.70	25.67	4.05	17.87	1.73	73.4	23.30
BX 1971 GLTP	*902*	**Tulare**	U	2.33	0.58	0.13	0.35	2.13	0.92	0.53	0.64	26.40	6.03	16.67	2.23	75.6	21.00
BX 1972 GLTP	*903*	**Tulare**	U	1.67	0.58	0.33	0.72	2.33	0.98	0.87	0.74	27.67	2.55	18.20	1.47	82.6	9.00
BX 1973 GLTP	*904*	**Tulare**	U	2.14	0.90	0.38	0.77	2.23	1.01	0.77	0.73	29.46	6.40	15.85	1.34	66.4	13.70
BX 1974 GLTP	*905*	**Tulare**	U	1.71	0.76	0.13	0.35	2.07	0.70	1.07	0.80	28.73	3.17	16.40	1.72	83.4	15.70
BX 1975 GLTP	*906*	**Tulare**	U	1.00	0.00	0.40	0.74	1.67	0.98	0.73	0.80	29.27	2.81	15.13	2.17	72.5	4.00
BX 1976 GLTP	*907*	**Tulare**	U	1.67	0.58	0.27	0.59	2.07	0.80	0.60	0.63	28.80	2.01	16.13	1.13	74.9	19.00
FM 1320 GL	*908*	**Tulare**	U	2.00	0.00	0.13	0.35	1.87	0.92	0.47	0.74	29.87	3.40	18.87	1.30	78.9	6.50
FM 1830 GLT	*909*	**Tulare**	U	2.00	0.00	0.27	0.46	1.60	0.83	0.33	0.62	31.07	2.40	17.60	1.80	82	12.70
FM 1888 GL	*910*	**Tulare**	U	1.86	0.38	0.47	0.83	1.93	1.10	0.40	0.63	29.60	2.92	16.73	1.62	84.6	8.60
FM 1911 GLT	*911*	**Tulare**	U	1.00	0.58	0.07	0.26	1.30	1.13	0.33	0.62	23.73	3.35	16.27	2.12	80.3	11.10
FM 1953 GLTP	*912*	**Tulare**	U	2.00	1.00	0.33	0.72	2.60	0.51	1.27	0.80	28.27	2.94	17.60	2.20	77.6	9.80
FM 2322 GL	*913*	**Tulare**	U	1.29	0.49	0.60	0.83	2.47	0.52	0.80	0.68	29.47	3.18	16.47	1.88	81	10.20

MEASUREMENTS SHOWN were made at approximately 7-8 weeks after plant emergence.

**** see NOTES section at the bottom of page 8 for additional information on the test screening site and suggestions for interpretation of results.***

Entry Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid)	Whole Plot Foliar FOV rating		Single Plant Foliar rating		Root Vasc. Stain Rating		Cotyledon Vasc. Stain Rating		Plant height (inches)		Main Stem Node #		Percent Survival	
				mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
FM 2334 GLT	914	Tulare	U	1.86	0.60	0.60	0.83	2.47	0.52	0.80	0.68	29.47	3.18	16.47	1.88	87.8	11.80
				23.00													
FM 2498 GLT	915	Tulare	U	2.14	0.38	0.86	0.80	2.36	0.74	0.93	0.73	27.21	5.96	15.93	2.09	68	5.90
FM 2574 GLT	916	Tulare	U	1.29	0.49	0.07	0.26	1.60	1.24	0.33	0.49	27.80	4.71	16.47	0.74	81.6	23.70
ST 4848 GLT	917	Tulare	U	1.14	0.38	0.13	0.52	2.13	0.99	1.20	0.77	28.87	3.83	16.20	2.11	76.6	12.90
ST 4949 GLT	918	Tulare	U	1.67	0.58	0.33	0.72	2.40	0.74	0.93	0.80	29.47	2.42	15.40	2.32	74.7	16.60
ST 5122 GLT	919	Tulare	U	1.14	0.38	0.33	0.62	2.20	0.86	0.73	0.46	30.12	3.79	17.60	2.10	71.6	15.50
ST 5517 GLTP	920	Tulare	U	1.71	0.76	0.33	0.62	2.33	0.72	0.80	0.77	29.60	7.10	17.73	3.35	80.9	19.50
ST 5471 GLTP	921	Tulare	U	0.43	0.79	0.20	0.41	2.07	0.80	1.27	0.88	28.20	2.86	16.33	1.11	87.3	9.80
ST 5818 GLT	922	Tulare	U	1.67	1.15	0.73	0.88	1.87	1.25	0.87	0.83	30.27	4.23	16.60	1.84	82.3	6.20
Bayer Daytona RF	923	Tulare	U	2.67	0.51	1.57	1.27	2.87	0.35	1.20	0.41	25.93	5.48	15.53	2.00	62.8	4.50
DP 1646 B2XF	924	Tulare	U	1.29	0.76	0.20	0.41	1.93	0.96	0.47	0.64	35.20	5.33	17.93	1.79	79.9	19.5
DP 1845 B3XF	925	Tulare	U	1.14	0.38	0.20	0.41	2.47	0.92	0.87	0.74	30.87	4.75	18.73	1.53	72.3	10.70
DP 1851 B3XF	926	Tulare	U	2.57	0.79	0.73	0.96	2.20	0.94	1.20	0.77	29.53	6.52	17.40	2.06	794	8.20

			Type of	Whole													
	2018	County	Cotton	Plot Foliar		Single		Root		Cotyledon		Plant		Main		Percent	
Entry	*Entry*	Location	(P-Pima; U-Upland	FOV		Plant Foliar		Vasc. Stain		Vasc. Stain		height		Stem		Survival	
Name	*Number*	SITE	H-Hybrid)	rating		rating		Rating		Rating		(inches)		Node #			
				mean	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*	*mean*	*stdev*
			(blank if information not provided														
MON 16R346 B3XF	*927*	**Tulare**		1.67	0.58	0.13	0.52	2.00	1.00	0.73	0.59	28.80	3.61	16.73	2.05	80.5	7.20
17R931 NR B3XF	*928*	**Tulare**		2.00	0.58	0.27	0.59	1.80	0.94	0.47	0.74	27.53	2.75	17.00	2.30	77.2	3.70
17R818 B3XF	*929*	**Tulare**		1.33	0.58	0.07	0.26	1.67	1.18	0.53	0.74	30.27	3.24	17.80	1.47	80.8	11.40
17R820 B3XF	*930*	**Tulare**		2.57	0.79	0.27	0.59	2.27	0.80	0.73	0.80	30.13	4.52	16.20	2.04	75.2	10.00
17R738 XF	*931*	**Tulare**		1.86	0.38	0.53	0.74	2.40	0.99	0.93	0.80	25.60	3.74	16.27	1.62	90.3	2.60
DP 341 RF	*932*	**Tulare**	P	0.14	0.38	0.00	0.00	0.87	0.83	0.00	0.00	27.67	2.97	17.47	1.73	94.4	3.90
DP 348 RF	*933*	**Tulare**	P	0.00	0.00	0.13	0.35	1.20	0.68	0.00	0.00	28.40	2.06	17.73	1.91	87.6	11.30
DP 358 RF	*934*	**Tulare**	P	0.67	0.58	0.20	0.41	1.27	0.70	0.13	0.35	29.67	3.02	18.33	1.54	85.7	8.30
DP 1725 B2XF	*935*	**Tulare**	U	0.33	0.58	0.00	0.00	1.33	0.72	0.00	0.00	28.00	3.05	17.40	1.68	88	3.80
DP 1747 NR B2XF	*936*	**Tulare**	U	0.67	0.58	0.27	0.46	1.60	0.63	0.20	0.41	29.07	3.28	17.53	1.96	94	2.70
DP 1820 B3XF	*937*	**Tulare**	U	0.33	0.58	0.07	0.26	1.42	0.80	0.07	0.26	28.00	2.20	16.80	2.11	94.4	1.30
18R445 B3XF	*938*	**Tulare**	U	2.00	0.00	0.54	0.97	1.85	0.90	0.77	0.93	25.92	6.28	16.62	3.80	56.9	11.10
18R409 B3XF	*939*	**Tulare**	U	0.14	0.38	0.07	0.26	1.52	0.94	0.13	0.35	26.47	2.61	16.93	1.16	82.1	15.60

Entry Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid) (blank if information not provided	Whole Plot Foliar FOV rating		Single Plant Foliar rating		Root Vasc. Stain Rating		Cotyledon Vasc. Stain Rating		Plant height (inches)		Main Stem Node #		Percent Survival	
				mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
18R432 B3XF	*940*	**Tulare**		1.00	1.00	0.40	0.74	1.73	0.80	0.67	0.72	31.67	3.70	17.13	1.30	89.8	6.60
18R440 B3XF	*941*	**Tulare**		1.29	0.49	0.60	0.74	2.47	0.64	1.07	0.70	29.47	4.36	17.80	1.78	78.8	6.30
18R639 NR B3XF	*942*	**Tulare**		1.00	1.00	0.20	0.56	1.18	0.86	0.07	0.26	27.00	1.41	17.27	1.44	86.6	9.70
18R628 NR B3XF	*943*	**Tulare**		0.14	1.38	0.00	0.00	1.33	0.88	0.07	0.26	26.80	2.43	16.67	2.06	89.8	14.00
18R525 B3XF	*944*	**Tulare**		0.67	0.58	0.07	0.26	1.27	0.70	0.00	0.00	28.27	4.13	17.93	2.12	83.7	6.60
16R246 NR B2XF	*945*	**Tulare**		0.14	0.38	0.00	0.00	1.67	0.62	0.13	0.35	28.13	1.46	18.53	1.06	92.1	5.20
Phy 841 RF	*946*	**Tulare**	P	0.29	0.49	0.47	0.74	0.87	0.70	0.00	0.00	27.60	1.80	17.87	0.92	91.6	8.40
Phy 881 RF	*947*	**Tulare**	P	0.67	0.58	0.00	0.00	1.13	0.74	0.00	0.00	27.27	2.09	17.67	1.99	88.1	7.20
Phy 888 RF	*948*	**Tulare**	P	1.33	0.58	0.00	0.00	1.40	1.06	0.40	0.63	31.40	3.46	17.20	1.70	87.7	12.50
Phy 805 RF	*949*	**Tulare**	P	1.71	0.49	0.07	0.26	1.87	0.99	1.00	0.85	30.53	2.70	17.80	1.37	82.7	10.30
Phy 802 RF	*950*	**Tulare**	P	1.14	0.38	0.07	0.26	1.33	1.05	1.07	0.80	29.87	3.72	16.20	1.93	85.4	7.30
Phy 444 WRF	*951*	**Tulare**	U	2.00	0.00	0.33	0.62	2.13	0.64	1.00	0.76	29.87	2.72	18.40	0.99	83.1	0.30
Phy 764 WRF	*952*	**Tulare**	U	1.00	0.00	0.07	26.00	1.73	0.70	0.53	0.64	31.27	1.62	17.93	1.16	96.1	3.40

Entry Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid) (blank if information not provided	Whole Plot Foliar FOV rating mean	stdev	Single Plant Foliar rating mean	stdev	Root Vasc. Stain Rating mean	stdev	Cotyledon Vasc. Stain Rating mean	stdev	Plant height (inches) mean	stdev	Main Stem Node # mean	stdev	Percent Survival mean	stdev
PX 803	*953*	**Tulare**		2.33	0.58	0.20	0.41	2.40	1.06	1.13	0.74	27.73	3.47	15.27	1.83	65.7	5.70
PX 804	*954*	**Tulare**		1.67	0.58	0.33	0.62	2.40	0.74	0.60	0.63	26.13	2.67	18.07	1.44	74.3	14.00
PX 806	*955*	**Tulare**		1.14	0.38	0.07	0.26	1.91	0.70	0.60	0.63	31.13	3.44	16.47	2.10	93	3.10
PX 807	*956*	**Tulare**		1.14	0.38	0.13	0.52	1.60	1.06	0.53	0.74	26.40	3.50	16.60	1.92	82.5	16.40
PX 808	*957*	**Tulare**		1.86	0.38	0.53	0.74	2.33	0.90	1.07	0.80	30.60	4.97	18.60	2.10	71.4	12.90
PX 809	*958*	**Tulare**		1.14	0.38	0.13	0.52	2.13	1.13	0.87	0.83	28.87	3.91	17.07	1.79	79.1	9.70
Ark 1015-42	*959*	**Tulare**	U-RBTN program	2.00	1.00	1.07	0.88	2.40	0.83	1.20	0.86	27.27	5.31	17.80	2.24	69	15.80
Ark 1005-41	*960*	**Tulare**	U-RBTN program	1.29	0.49	0.27	0.59	2.07	0.96	0.53	0.74	29.40	4.82	17.87	2.95	76.3	12.60
Ark 1004-38	*961*	**Tulare**	U-RBTN program	1.67	1.15	0.40	0.74	2.33	0.72	0.80	0.77	32.20	8.18	17.93	1.71	67.9	23.40
Ark 1005-35	*962*	**Tulare**	U-RBTN program	1.14	0.38	0.20	0.41	1.60	0.83	0.67	0.72	30.13	3.34	17.00	1.73	90	7.20
Ark 1007-15	*963*	**Tulare**	U-RBTN program	1.67	1.15	0.33	0.62	1.87	1.30	0.80	0.77	29.80	6.01	16.73	2.12	83.7	14.00
16-13P1115	*964*	**Tulare**	U-RBTN program	1.67	0.58	0.33	0.72	1.73	1.28	0.80	0.86	32.60	4.31	17.20	2.31	81.1	17.60
TAM LBB 150107	*965*	**Tulare**	U-RBTN program	1.29	0.49	0.27	0.70	2.07	1.10	0.87	0.83	31.53	3.52	18.53	2.85	77.6	15.50

-3 Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid) (blank if information not provided	Whole Plot Foliar FOV rating mean	stdev	Single Plant Foliar rating mean	stdev	Root Vasc. Stain Rating mean	stdev	Cotyledon Vasc. Stain Rating mean	stdev	Plant height (inches) mean	stdev	Main Stem Node # mean	stdev	Percent Survival mean	stdev
TAM LBB 150824	*966*	**Tulare**	U-RBTN program	1.00	0.00	0.47	0.83	2.07	0.88	1.20	0.94	33.93	5.32	18.27	2.02	71.3	4.90
TAM LBB 150921	*967*	**Tulare**	U-RBTN program	2.00	1.00	0.60	0.83	2.13	0.83	0.87	0.74	30.60	5.53	17.60	1.88	76.3	13.80
GA 2012141	*968*	**Tulare**	U-RBTN program	1.33	1.15	0.33	0.72	1.73	1.22	0.67	0.72	27.87	4.63	15.40	1.80	75.1	20.40
GA 2015024	*969*	**Tulare**	U-RBTN program	1.00	0.00	0.13	0.35	1.60	1.06	0.40	0.63	35.61	4.14	19.60	1.18	88.4	13.60
TAM 13S-03	*970*	**Tulare**	U-RBTN program	1.33	0.58	0.40	0.74	2.07	0.88	0.60	0.74	26.87	4.56	17.40	2.06	86	14.30
TAM 12J-39	*971*	**Tulare**	U-RBTN program	2.00	0.00	0.33	0.72	1.87	0.99	0.87	0.92	27.27	7.31	16.87	1.51	88.3	15.60
LA 14063083	*972*	**Tulare**	U-RBTN program	1.29	0.49	0.20	0.56	2.53	0.99	0.80	0.68	25.87	4.31	16.67	1.99	82.4	11.10
LA 14063075	*973*	**Tulare**	U-RBTN program	1.14	0.38	0.07	0.26	1.53	0.74	0.40	0.63	25.93	3.06	15.33	2.13	79.5	13.70
LA 11309040	*974*	**Tulare**	U-RBTN program	1.00	0.00	0.40	0.51	2.47	0.64	0.60	0.63	28.87	3.64	17.20	1.52	82.4	17.50
PD 2011 021	*975*	**Tulare**	U-RBTN program	1.00	0.00	0.20	0.41	2.00	0.76	0.67	0.72	28.67	4.32	17.27	1.79	90.4	2.40
PD 2011 081	*976*	**Tulare**	U-RBTN program	1.71	0.49	0.33	62.00	1.60	1.24	0.33	0.49	26.73	8.46	16.67	1.54	76.9	17.60
PD 2011 026	*977*	**Tulare**	U-RBTN program	1.14	0.38	0.13	0.35	1.73	1.16	0.47	0.74	31.73	2.99	16.20	1.32	81.4	5.30
MS 2010-87-5	*978*	**Tulare**	U-RBTN program	1.00	0.00	0.33	0.49	2.20	0.68	0.60	0.63	31.00	3.25	18.33	1.11	92.3	9.50

Entry Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid) (blank if information not provided	Whole Plot Foliar FOV rating		Single Plant Foliar rating		Root Vasc. Stain Rating		Cotyledon Vasc. Stain Rating		Plant height (inches)		Main Stem Node #		Percent Survival	
				mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
DP 393 *RBTN check*	*979*	**Tulare**	U	0.29	0.49	0.00	0.00	1.27	1.16	0.27	0.59	29.73	3.20	16.80	1.66	89.1	2.70
DP 493 *RBTN check*	*980*	**Tulare**	U	1.00	0.00	0.07	0.26	1.40	1.12	0.20	0.41	28.33	3.37	17.67	1.88	88.6	1.30
FM 958 *RBTN check*	*981*	**Tulare**	U	1.29	0.76	0.27	0.59	1.20	1.37	0.40	0.63	29.80	4.69	16.53	1.73	73.4	16.20
UA 222 *RBTN check*	*982*	**Tulare**	U	2.00	0.00	0.33	0.62	2.47	0.64	0.67	0.72	29.73	3.22	18.13	2.47	73.1	15.30
CPS 18501-A B3XF	*983*	**Tulare**		2.00	0.00	0.27	0.59	2.87	0.52	1.27	0.70	28.40	4.61	16.33	1.45	77.7	12.80
CPS 18502-A B3XF	*984*	**Tulare**		1.00	1.00	0.07	0.26	2.13	1.13	0.60	0.63	27.47	4.49	18.20	1.08	87.7	3.80
CPS 18501-B B3XF	*985*	**Tulare**		1.67	0.58	0.20	0.41	2.20	0.94	1.00	0.93	31.13	3.09	16.60	1.76	83.2	9.90
CPS 18501-C B3XF	*986*	**Tulare**		1.00	0.00	0.27	0.46	1.87	0.99	0.73	0.59	32.33	2.74	16.87	1.64	81.8	6.00
CPS 18503-A B3XF	*987*	**Tulare**		1.33	0.58	0.13	0.35	2.20	0.86	0.67	0.72	31.33	2.77	19.00	1.93	88.6	4.50
CPS 18503-D B3XF	*988*	**Tulare**		2.00	1.00	0.33	0.62	1.93	1.22	0.80	0.86	32.07	8.54	17.67	1.63	74.1	17.90
CPS 18505-C B3XF	*989*	**Tulare**		1.00	0.00	0.13	0.35	1.40	1.24	0.53	0.74	34.87	4.56	17.27	2.74	92.1	3.10
CPS 18506-D B3XF	*990*	**Tulare**		1.33	0.58	0.27	0.46	2.13	0.64	0.67	0.82	29.07	5.64	16.40	1.92	78.1	11.1

Entry Name	2018 Entry Number	County Location SITE	Type of Cotton (P-Pima; U-Upland H-Hybrid) (blank if information not provided	Whole Plot Foliar FOV rating		Single Plant Foliar rating		Root Vasc. Stain Rating		Cotyledon Vasc. Stain Rating		Plant height (inches)		Main Stem Node #		Percent Survival	
				mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
HA 1432	*991*	**Tulare**	H	1.67	0.58	0.60	0.83	2.00	1.00	0.73	0.59	28.67	6.03	15.93	1.98	78.8	8.70
Phy 499 WRF	*992*	**Tulare**	U	1.00	0.00	0.20	0.41	1.53	0.99	0.47	0.74	37.07	4.89	17.73	1.28	98.9	1.90
NG 4545 B2XL	*993*	**Tulare**	U	1.33	0.58	0.53	0.74	2.27	0.80	0.67	0.72	32.53	3.02	17.87	1.19	84.3	2.80
DP 149 B2XF	*994*	**Tulare**	U	1.33	1.15	0.40	0.63	2.33	0.62	1.07	0.80	33.67	4.92	17.93	1.75	77.1	11.20
DG 2355 B2RF	*995*	**Tulare**	U	1.00	0.00	0.27	0.46	1.60	0.91	0.40	0.63	33.67	2.47	17.93	1.22	97.4	2.40
DP-340	***check A***	**Tulare**	P	3.00	0.63	0.62	0.80	2.54	0.81	0.69	0.47	14.32	5.98	13.05	1.77	20.5	12.90
	moderate to high																
	susceptibility																
Phy 881 RF	***check B***	**Tulare**	P	0.11	0.32	0.07	0.25	1.23	0.86	0.03	0.18	25.80	3.29	16.20	2.17	84.4	16.40
	highly tolerant																
Mon 109-C7	***check C***	Tulare	P	2.57	0.53	0.35	0.65	2.61	0.99	0.74	0.75	17.48	4.10	12.78	2.17	18.5	11.60
	high susceptibility																

NOTES: The Tulare County site is a naturally infested field site where presence of the race 4 Fusarium pathogen had been confirmed in prior pathology studies. Averages and standard deviations of data are shown.
This site had a moderately severe infestation of Race 4 Fusarium (Hutmacher assessment), and observed symptoms were much more severe than in 2016-2017 at the same farm research site.
For screening purposes for race 4 Fusarium resistance, at this site & year we consider Vascular Root Staining numbers of 1.5 or lower as having some useful levels of resistance, worth considering for more field screening tests.

In general, we consider the data shown in columns "Root Vascular Staining" and "Percent Survival" as the most useful information for assessments of relative resistance to the FOV-4 pathogen. Foliar damage levels are often not a clear indicator of plant infection or disease severity. Vascular staining at the cotyledon node is less consistent than tap root vascular staining. Plant growth measurements (plant height, # of nodes) shown are just measured as relative indicators of impacts on plant vigor and growth.

Foliar Damage/Disease Severity Index scale: 0 = no symptoms; 1 = epinasty and slight dwarfing; 2 = 1 to30% of leaves chlorotic; 3 = 31 to 80% of leaves chlorotic and severe stunting;4= 81 to 100% of leaves chlorotic; and 5 = plant death.

Root Vascular Staining Index scale: 0 = no vascular root staining evident, 1 = light vascular root staining evident as spotty areas; 2 = more continuous than 1,but light colored staining covering an area between one quarter and one half of the stem crosssection; 3 = moderate brown/black staining evident in a band encircling most of the stem cross section;4 = brown/black staining evident across most vascular tissue in stem cross section, and 5 = plant severely damaged or plant death with staining seen throughout a cross-section of root tissue (Ulloa et al. 2006, 2009a).