Final Report 6/30/2014

2013 Greenhouse Bucket CET for Screening Herbicides for Activity on Flowering Rush Leaf Injury 4 Months & "2nd Growing Season" after Treatments

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Flowering rush (*Butomus umbellatus)* plugs (roots, rhizome, and sediment) were extracted from the bed of Flathead Lake (Montana) in May 2013. The 11 inch diameter plugs were trimmed to 6 inched in depth, placed in 6.5 gallon buckets, and transferred to a greenhouse at the University of Montana. Herbicide treatments were initiated on May 28, 2013 when the emerging leaves averaged 16.5 inches in height (9 inches below the water line, 7.5 inches above the water line) (Table 1). Replication was limited to 4 or 5 buckets for each treatment. The bucket water was 64° F at the start of the herbicide injections. Buckets were drained and refilled with clean water 6 times at the termination of the exposures

Table 1. Treatment schedule.

Trt#	**Product**	**Label Rate**	**ppm**	**Exposure Duration**
1	Renovate OTF	mid	1.5	14
2	Renovate OTF	high	2.5	14
3	Renovate Max	mid	2.5	14
4	Renovate Max	high	5	14
5	Sonar ONE	mid	0.09	14
6	Sonar ONE	high	0.15	14
7	Hydrothol 191	mid	2.75	24HAT
8	Hydrothol 191	high	5	24HAT
9	Diquat (370ppb) / Renovate OTF	high/mid	0.37/1.5	24HAT / 14DAT
10	Diquat (370ppb) / Renovate OTF	high/high	0.37/2.5	24HAT / 14DAT
11	Diquat (370ppb) / Renovate Max	high/mid	0.37/2.5	24HAT / 14DAT
12	Diquat (370ppb) / Renovate Max	high/high	0.37/5	24HAT / 14DAT
13	Diquat (370ppb) / Sonar ONE	high/mid	0.37/0.09	24HAT / 14DAT
14	Diquat (370ppb) / Sonar ONE	high/high	0.37/0.15	24HAT / 14DAT
15	Oasis	low	0.015	3
16	Oasis	mid	0.03	3
17	Oasis	high	0.05	3
18	Oasis / Competitor surfactant	low	0.0325	Foliar
19	Oasis / Competitor surfactant	mid	0.065	Foliar
20	Oasis / Competitor surfactant	high	0.13	Foliar
21	**Untreated Control**	**UTC**	**UTC**	**UTC**

4 MAT Response Parameters:

- dry weight (g): oven dry weight in grams of normal green leaf tissue
- % control: efficacy based on reduction in dry weight compared to untreated control
- necrotic %: proportion of test bucket leaf tissue brown or black
- chlorotic %: proportion of test bucket leaf tissue yellow
- bleached %: loss of leaf chlorophyll to where the leaf tissue is white
- visible injury %: summation of % necrotic + chlorotic + bleached
- excess injury %: visible injury % for treatment group minus that observed for untreated controls
- collapsed %: proportion of test bucket leaves that have lust turgor and dropped to bottom of bucket
- sum of leaf injury %: cumulative percentages for necrotic + chlorotic + bleached + collapsed, can add to 200%
- thickened %: proportion of green leaves that are swollen in cross section relative to normal narrow linear leaf form, this symptom has been observed in previous trials with Renovate Max
- regrowth %: proportion of short recently emerged green leaves

"Second Growing Season" Response Parameters:

- dry weight (g): oven dry weight in grams of normal green leaf tissue
- % control: efficacy based on reduction in dry weight compared to untreated control

Percent control at 4 months after treatment and in the "second growing season" after treatment are presented in Table 2. The means for visible injury response parameters at 4 months after treatment are summarized in Table 3. There was little visible injury in the second post-treatment growing season except some bleaching in the treatments that included the high rate of Sonar One.

Figure 1 illustrates efficacy as percent control (± one standard error) 4 months after treatment calculated from the dry weight of normal green tissue; Figure 2 is percent control in the "second growing season" after treatment. Figure 3 illustrates visible injury % (± one standard error) 4 months after treatment. These data suggest in general that at 4 months after treatment the prescriptions that included Sonar One and the Oasis foliar application were most efficacious.

The 4 MAT visual injury scorings and leaf harvesting/dry weight determinations were done in early October when the untreated controls were undergoing normal fall senescence. This was intentional so there was a greenhouse simulation of the phenological progress of flowering rush following herbicide treatment in a natural water body. Because of the resiliency of the rhizomes, the response parameter of most interest would be the dry weight of green leaf production at peak biomass in the second growing season (2014) after the herbicide treatments. The plants/plugs (rhizomes & roots) were subjected to winter cold (freezing) treatment from late October 2013 through February 2014. Then the buckets were returned to the heated greenhouse to stimulate "second growing season" regrowth. The second post-treatment normal green tissue biomass harvest was made April 21, 2014. There was strong recovery of leaf growth in the second growing season. Only the Diquat/Sonar One high rate/high rate 1d/14d exposure treatment provided significant second year suppression at $p \leq 0.10$ with control being just 60%. Second year suppression by Sonar One high rate 14d exposure was 50% at $p=0.20$. There was little visible injury in this second post-treatment growing season except some bleaching in the treatments that include the high rate of Sonar One.

Table 2. Mean normal green tissue dry weight, percent control, and visible injury parameters 4 months (Oct 4-6, 2013) and "second growing season" (Apr 21, 2014) after treatments made May 28, 2013.

herbicide rate duration	dry weight (g)	% control	p.	dry weight (g)	% control	p.
Renovate OTF mid 14d	15.1	-20.5	0.998	21.4	-76.2	1.000
Renovate OTF high 14d	19.0	-51.0	1.000	17.0	-40.2	1.000
Renovate Max mid 14d	12.5	0.7	0.953	20.4	-67.6	1.000
Renovate Max high 14d	8.9	29.0	0.513	15.0	-23.3	0.998
Sonar ONE mid 14d	11.3	10.4	0.865	14.6	-20.5	0.997
Sonar One high 14d	**1.0**	**91.8**	**0.001**	6.0	50.3	0.200
Hydrothol 191 mid 1d	9.3	25.9	0.616	9.4	22.4	0.732
Hydrothol 191 high 1d	12.8	-1.8	0.965	13.7	-12.4	0.990
Diquat/Renovate OTF high/mid 1d/14d	13.5	-7.7	0.985	19.1	-57.0	1.000
Diquat/Renovate OTF high/high 1d/14d	12.6	-0.4	0.958	18.5	-52.1	1.000
Diquat/Renovate Max high/mid 1d/14d	14.4	-14.7	0.995	18.0	-48.1	1.000
Diquat/Renovate Max high/high 1d/14d	10.9	12.9	0.830	17.9	-47.6	1.000
Diquat/Sonar One high/mid 1d/14	11.5	8.7	0.886	14.6	-20.5	0.997
Diquat/Sonar One high/high 1d/14	**3.2**	**74.1**	**0.009**	**4.9**	**60.0**	**0.096**
Oasis low 3d	21.1	-68.3	1.000	17.6	-44.9	1.000
Oasis mid 3d	16.8	-34.1	1.000	20.8	-71.3	1.000
Oasis high 3d	19.0	-51.7	1.000	22.1	-82.2	1.000
Oasis low foliar	**5.2**	**58.4**	**0.058**	19.1	-57.3	1.000
Oasis mid foliar	**3.4**	**72.7**	**0.011**	18.1	-49.3	1.000
Oasis high foliar	**5.3**	**57.7**	**0.063**	16.0	-32.1	1.000
untreated control	12.6	0.0	0.998	12.1	0.0	1.000

Larger bolded means are significant at p≤0.10 based one sided Dunnett t-tests against the untreated control.

Negative means are measured responses opposite the anticipated herbicide effect.

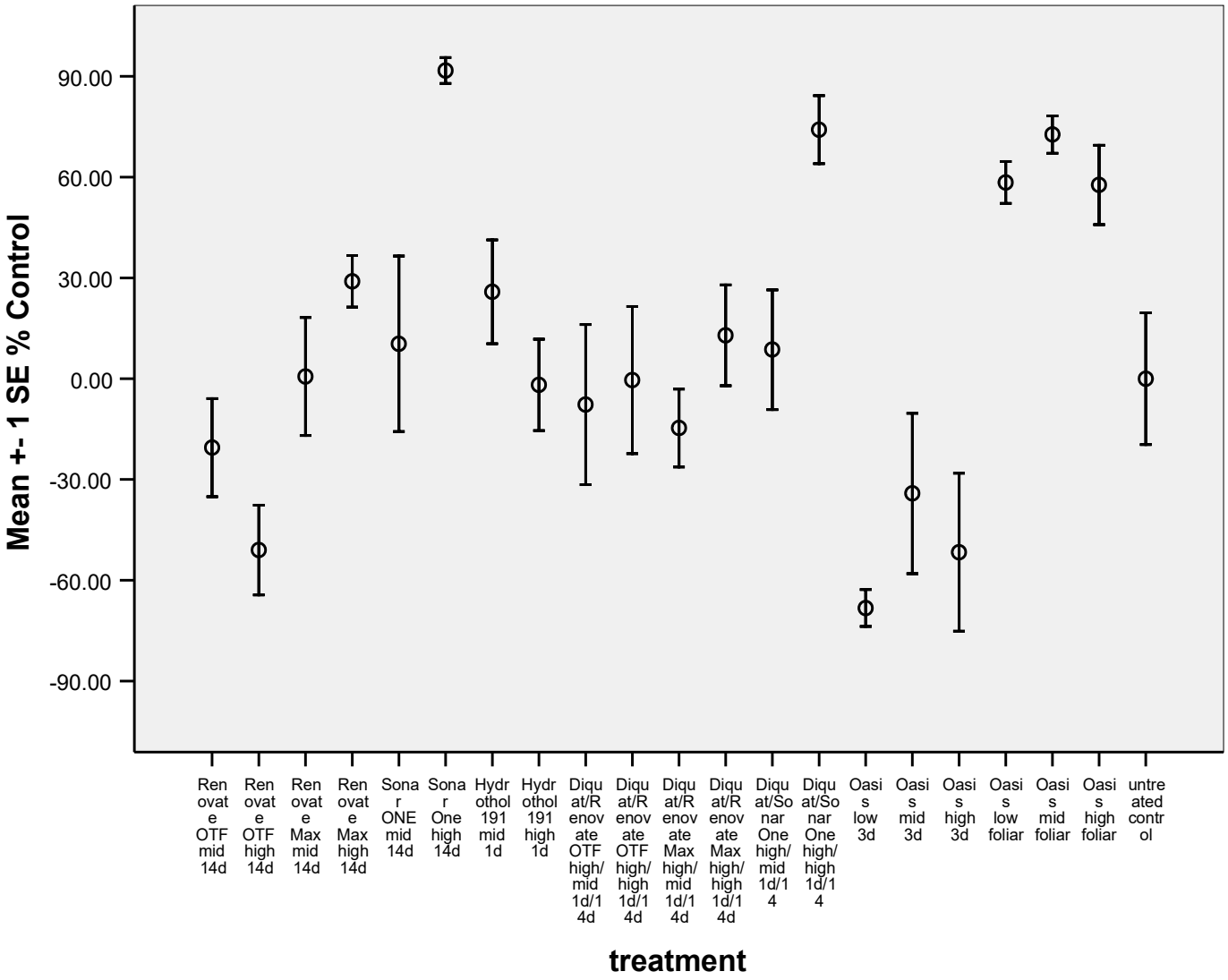

Figure 1. Percent control (± one standard error) 4 months after treatment calculated from dry weight of normal green tissue.

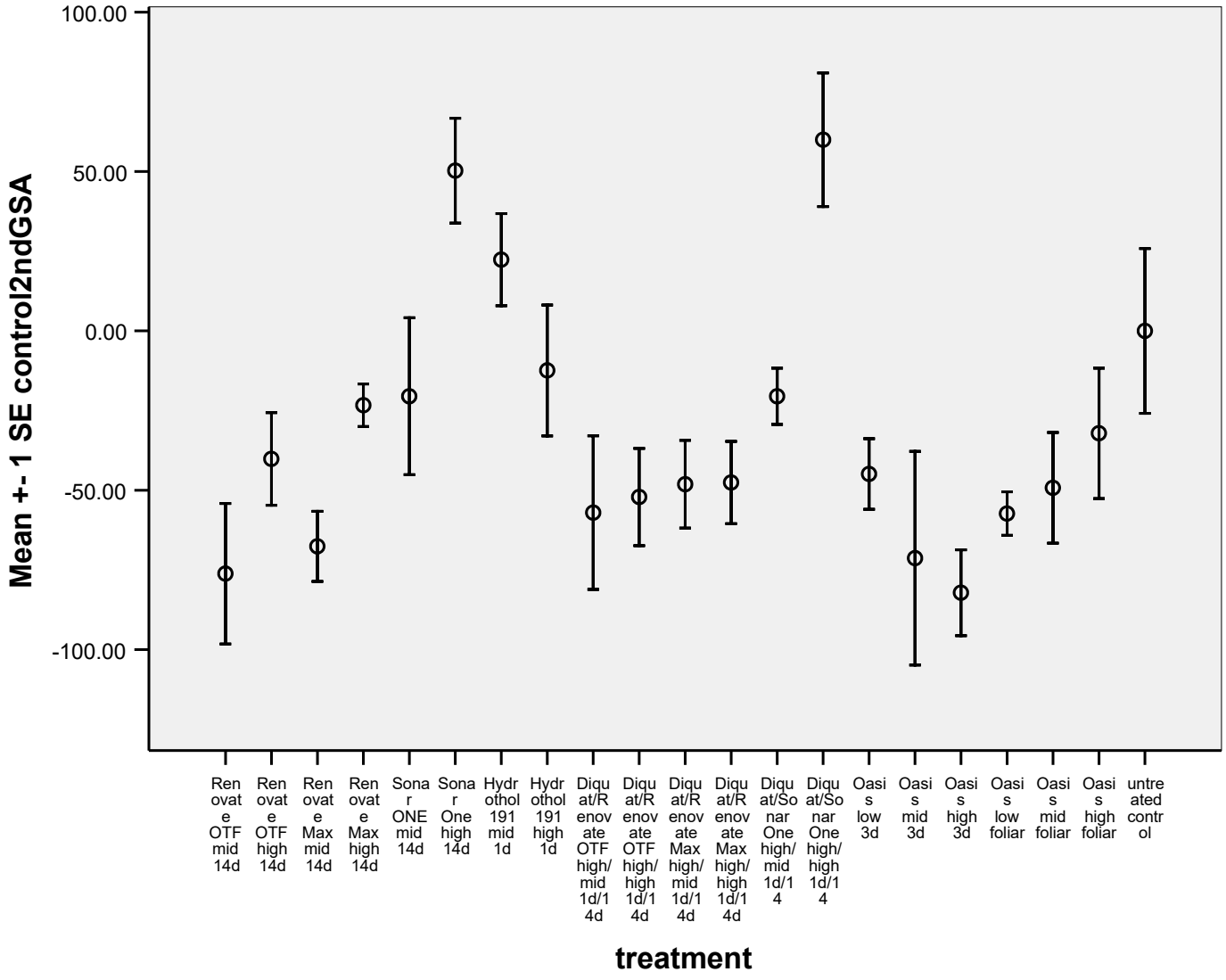

Figure 2. Percent control (± one standard error) 2nd growing season after treatment calculated from dry weight of normal green tissue.

Table 3. Mean normal green tissue dry weight, percent control, and visible injury parameters 4 months (Oct 4-6, 2013) after treatments.

herbicide rate duration	dry weight (g)	% control	necrotic %	chlorotic %	bleached %	visible injury %	excess injury %	collapsed %	sum leaf injury %	thickened %	regrowth %
Renovate OTF mid 14d	15.1	-20.5	28.0	10.0	2.0	40.0	-4.0	18.0	58.0	0.0	3.6
Renovate OTF high 14d	19.0	-51.0	20.0	10.0	2.0	32.0	-12.0	0.0	32.0	0.0	6.6
Renovate Max mid 14d	12.5	0.7	34.0	6.0	2.0	42.0	-2.0	24.0	66.0	0.0	5.2
Renovate Max high 14d	8.9	29.0	10.0	2.0	0.0	12.0	-32.0	4.4	16.4	**44.0**	3.0
Sonar ONE mid 14d	11.3	10.4	36.0	4.0	**55.4**	**95.4**	**51.4**	16.0	**111.4**	0.0	12.2
Sonar One high 14d	**1.0**	**91.8**	**97.8**	0.0	2.2	**100.0**	**56.0**	**95.8**	**195.8**	0.0	12.4
Hydrothol 191 mid 1d	9.3	25.9	37.5	10.0	0.0	47.5	3.5	12.5	60.0	0.0	4.3
Hydrothol 191 high 1d	12.8	-1.8	35.0	10.0	2.5	47.5	3.5	10.0	57.5	0.0	2.8
Diquat/Renovate OTF high/ mid 1d/14d	13.5	-7.7	16.0	9.0	0.0	25.0	-19.0	8.0	33.0	0.0	6.8
Diquat/Renovate OTF high/ high 1d/14d	12.6	-0.4	21.0	11.0	0.0	32.0	-12.0	0.0	32.0	0.0	3.8
Diquat/Renovate Max high/ mid 1d/14d	14.4	-14.7	14.0	4.0	0.0	18.0	-26.0	2.0	20.0	32.0	6.2
Diquat/Renovate Max high/ high 1d/14d	10.9	12.9	8.0	1.0	0.0	9.0	-35.0	2.0	11.0	**64.0**	10.4
Diquat/Sonar One high/mid 1d/14	11.5	8.7	16.0	4.0	**54.0**	**74.0**	**30.0**	2.0	76.0	0.0	11.2
Diquat/Sonar One high/high 1d/14	**3.2**	**74.1**	56.4	0.0	24.0	**80.4**	**36.4**	**52.0**	**132.4**	**40.0**	**18.2**
Oasis low 3d	21.1	-68.3	17.5	**25.0**	2.5	45.0	1.0	5.0	50.0	0.0	4.5
Oasis mid 3d	16.8	-34.1	18.8	13.8	0.0	32.5	-11.5	0.0	32.5	0.0	5.5
Oasis high 3d	19.0	-51.7	13.8	2.5	0.0	16.3	-27.8	10.0	26.3	0.0	3.0
Oasis low foliar	**5.2**	**58.4**	24.0	12.0	4.0	40.0	-4.0	12.0	52.0	0.0	3.0
Oasis mid foliar	**3.4**	**72.7**	28.0	6.0	6.0	40.0	-4.0	18.0	58.0	0.0	2.8
Oasis high foliar	**5.3**	**57.7**	32.0	2.0	**42.0**	**76.0**	**32.0**	30.0	**106.0**	0.0	5.2
untreated control	12.6	0.0	32.0	10.0	2.0	44.0	0.0	2.0	46.0	0.0	6.4

Larger bolded means are significant at p≤0.10 based one sided Dunnett t-tests against the untreated control.

Negative means are measured responses opposite the anticipated herbicide effect.

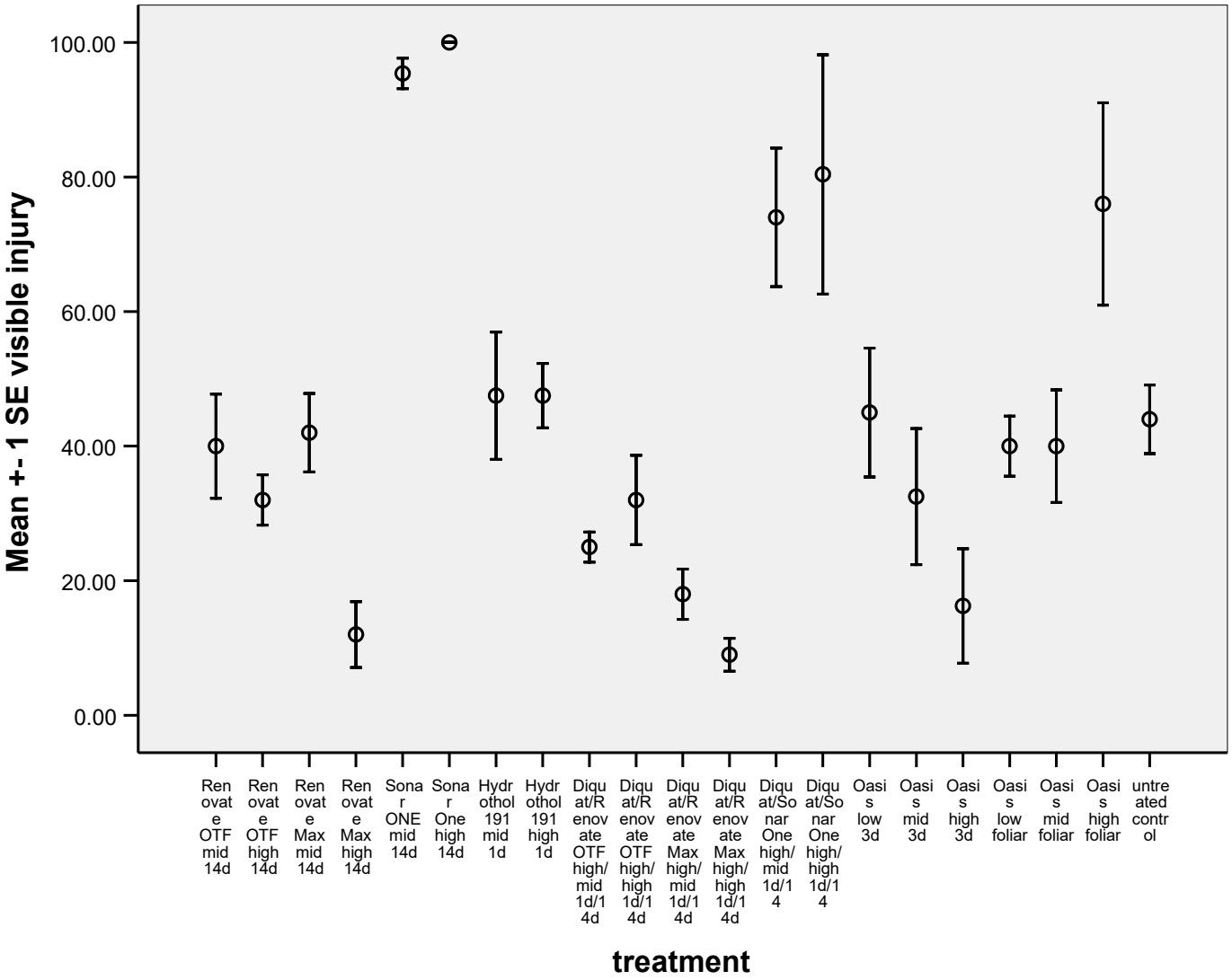

Figure 3. Total visible injury (± one standard error) 4 months after treatment.