

Ref 62
The Effects of Road Dust Control with Magnesium Chloride on
the local Flora of the Rocky Mountain Biological Laboratory,
Gothic, Colorado

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A Research Paper

By

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Biology 500
Field Botany

Summer 1999

RMBL Library

BT
see my
comments on
the "Appendix"
page... M.C.

The Effects of Road Dust Control with Magnesium Chloride on the Local Flora of the Rocky Mountain Biological Laboratory, Gothic, Colorado

Introduction:

According to Solarchem Resources (1999), a subsidiary of Cargill and makers of Dust-Off, an anticorrosive dust suppressant containing magnesium chloride, most dust control agents work basically in the same way. They dampen and penetrate unpaved road surface causing fine particles to hold together. Dust-Off is considered to perform this job better than most other dust suppressants because its magnesium chloride formula is hygroscopic. A similar product containing magnesium chloride is marketed by Envirotech Services, Inc. (1999) and is sold under the name of Dustgard®.

*can it be
"formula"
of MgCl₂
it hygroscopic*

Magnesium chloride is a naturally occurring mineral and is extracted from salt water solutions such as sea water, the Great Salt Lake, and the Dead Sea (Thunder Sword Resources, Inc., 1999). Under MSDS listings of Cornell University (1999), magnesium chloride (hexahydrate) CAS #7786-30-3 is given a precaution: hygroscopic material. When first opened, it appears dry; it quickly absorbs moisture from the air and softens. Solarchem Resources (1999) further adds that Dust-Off, containing this material, has a low level of toxicity to humans, but should not be applied directly to plants since it can act as a defoliant. Also, a further admonition is that it not be applied 1) if a domestic drinking water source is less than 25 feet below the surface of application or 2) where it can be washed into ponds or streams. However, Solarchem (1999) asserts that this material has been shown to be environmentally friendly by the

Acknowledgements

I would like to acknowledge the help given to me by the Gunnison County Road Department for the information and materials given to me to complete this project.

Thanks to my husband , Ron, who helped me to dispense the magnesium chloride solution to the appropriate areas.

Many thanks to the Faculty and Staff at RMBL who have made this a fantastic summer.

Thanks to Dr. Michael Kelrick for his encouragement.

*You are most
welcome, Rosie.
M.K.*

Rosemary Hackney
Summer 1999

Field Botany Bio 500

EPA and U.S. Construction Engineering Research Laboratory, as well as by the U.S. Forest Service and the U.S. Army Corps of Engineers.

a bit of a non-significant result...
According to Crawford (1989), the means by which plants survive exposure to high concentrations of salt vary with the manner in which the salt enters the plant tissue. He

some transitional introductory language is appropriate...
states that when the salt is deposited on foliage, then most plants attempt to resist the uptake of excessive amounts by means of various exclusion processes.

However, when the roots are involved in saline habitats, the plants exist by coming into equilibrium with the salt concentrations in the soil by secretion processes that involve specialized organs that rid the plant of excess salt.

Crawford (1989) divides salt-tolerant vegetation into two physiological groups:

are there the same answers?
osmoregulators and osmoconformers [Plants growing in saline soils can have tissue water potentials in healthy, unwilted leaves in the range of -2 to -3 MPa.] The dividing line

EXPLAIN!
between osmoregulators and osmoconformers is designated as -2 MPa. Osmoregulation as the sole means of surviving in saline habitats is an adaptation of only limited value since prolonged exposure to high salt eventually leads to failure of the exclusion

mechanisms. In comparison to salt-tolerant vegetation, leaf water potentials of -1.2 to -1.6 MPa in crop plants are found only in leaves of wilted plants. Well-watered leaves generally have water potentials of -0.2 MPa or more positive.

Alterations to solute or osmotic potential can occur by either accumulation of solutes taken up from the external medium or by synthesis of organic solutes within the plant. A third possibility is the reduction of cell water content by dehydration. Given that halophytes, plants which tolerate or thrive in saline or alkaline soils, and glycophytes,

plants that are able to thrive in soils of low salt concentration, usually less than 0.5%

NaCl, do not differ at the molecular level in their sensitivity to salt, their ability to

function with high tissue contents of NaCl, specifically the chlorine ion, must be

dependent on some degree of compartmentation within the cell. [The bulk of which is

stored in the vacuole.] *This is not a sentence* In response to compartmentation of NaCl in the vacuole, other

compounds are synthesized in the plants to function as compatible cytoplasmic solutes.

Among these are the amino acid *proline* and the quaternary ammonium compound,

glycine betaine. Other methylated onium compounds have been shown to occur.

(Crawford, 1989).

Some plants, whose roots are not immersed in salt-containing water or soil, still must be

resistant to salt spray. For this, they need some short-term avoidance of salt injury.

Tolerance to moderate salt exposure *in the air* appears to rest on prevention of salt accumulation in

the shoot. In comparisons of salt-sensitive and salt-tolerant crop plants, it was found that

the salt-tolerant varieties were able to maintain lower levels of chlorine in their leaves

than the sensitive ones. In the sensitive plants, the high level of chlorine in the leaf was

due to rapid uptake in the root coupled with rapid transport to the shoot. Control of salt

accumulation is considered by four categories: exclusion, excretion, succulence, and

passive removal (Crawford, 1989).

Exclusion involves the development of a double epidermis which retards the passage of

salt into the xylem. Excretion involves the active removal of salt from the xylem by

specialized organs. Succulence, which *may* develop in response to salts, is due to an increase

in the volume of the cells of the spongy mesophyll. It is usually accompanied by other

doesn't this contradict the statement at the beginning of the PP that you are discussing plants for which root uptake is not the main salt exposure route

morphological changes. The thickening of the leaf increases its volume and at the same time reduces the surface area to volume ratio. Passive removal of salt occurs by the shedding of the mature leaves. The death of these leaves may be hastened by the amount of salt they absorb (Crawford, 1989).

In conclusion, the common result, survival in saline conditions, is achieved in various ways with some plants allowing accumulation of salt in certain organs, such as old leaves, and even within the cell vacuoles. It is even possible for exclusion mechanisms to operate. However, as salt increases in the soil water, these mechanisms eventually fail (Crawford, 1989).

Purpose:

The purpose of this research is to see if there are any adverse reactions observed in the flora located next to a magnesium chloride spray area located along the side of county road 317 that passes through the Rocky Mountain Biological Laboratory.

Methods and Materials:

Flora analyzed in this experiment included the species cow parsnip (Heracleum sphondylium ssp. montanum) and Pyrocoma crocea, located on the western side of county road 317 in Gothic between the upper and lower roads entering Happy Valley.

Plants were measured from the distance of the spray area and classified into three damage groups: (A) severe damage including chlorosis, necrosis, or death of leaves or plants; (B) slight damage, including mild discoloration or wilting; (C) no damage apparent in the plant. The amount of damage exhibited or not exhibited by a plant was compared to

would you test the nature of the reaction to determine if the plants are damaged

To document the impact of application of magnesium chloride spray on the vegetation in the area of the road

Plants themselves were

not damaged

its position to the spray line of magnesium chloride.

Using the data that were collected from measuring the distance of the stems from the spray line and the damage that was exhibited at each distance (Appendix, Tables I & II), an ^{application} experimental distance from the stems was determined ^{for use in an experimental} as a choice test site to apply the magnesium chloride. Most damage exhibited in the Heracleum ranged from 20-40 cm ^{from} So 30 cm from the stems was chosen as an intermediate distance to apply the magnesium chloride in Heracleum. In the Pyrrocoma, most damage was exhibited between 10-30 cm. So 20 cm from the stems was chosen as an intermediate distance to apply the magnesium chloride from Pyrrocoma.

Information obtained from the Gunnison County Roads Department indicated that a 28% -32 % solution of magnesium chloride was sprayed on the county dirt roads for dust suppression. The solutions were ordered in a 28% solution from Gemco, Inc. in Grand Junction, Colorado. But, throughout the summer, the concentration would increase up to 32% ^{whose effects were due to} as water evaporated from the holding tanks. But since the spraying was ^{as discussed} early June, the Director seemed certain the concentration of sprayed solution was 28% magnesium chloride. The Roads Department Director gave me approximately 2 liters of the magnesium chloride solution from their holding tanks to perform my experiment.

An experiment was designed to determine if the effects observed from the spraying of magnesium chloride were due to salt solution concentrations of magnesium chloride causing damage by ^{uptake by} ~~pulling water from the~~ plants via the roots, or, if the effects of

magnesium chloride were as a defoliate, ~~damaging~~ ² to the leaves by direct spray contact.

Using the 28% magnesium Chloride that was supplied by the Gunnison County Roads Department, I applied the solution to the test plants as follows: (A) Application of magnesium chloride 30 cm from the stems of Heracleum; (B) Application of magnesium chloride to intact leaves of Heracleum; (C) Application of magnesium chloride 20 cm from the stems of Pyrrocoma; (D) Application of magnesium chloride to intact leaves of Pyrrocoma; (E) Control Group - no treatment.

Treatment plants were selected for Heracleum along the north road into Happy Valley. Six test plants were chosen for the leaf applications of magnesium chloride and six test plants were selected for root applications of magnesium chloride. On the plants selected for leaf treatment, both an upper and a lower, intact, green leaf were selected.

The 28% magnesium chloride was applied by a squirt bottle on the selected leaves. This was in an attempt to duplicate direct contact spraying from the county spray truck. since there was evidence of direct spray contact ^{from observing} by the spray line ~~from the application truck~~ ^{location of the county truck}.

For root treatment, a meter stick was used to measure 30 cm from the stem area and the magnesium chloride was applied in a straight line perpendicular to the stems to duplicate spraying along the road.

Treatment plants were selected for Pyrrocoma along the south road into Happy Valley. Six plants were chose for the leaf applications of magnesium chloride and six plants were chosen for the root treatments of magnesium chloride. ^{As above,} Two leaves were

selected per plant for the leaf treatment, ~~an upper and a lower~~. On the plants selected for

root treatment, magnesium chloride was applied 20 cm from each plant stem. The 28% magnesium was applied with a squirt bottle as in the Heracleum application.

The control plants was selected at the intersection of North Happy Valley Road and Gunnison County Road 317 between the north side of Happy Valley Road and Swallows Nest cabin and west of Gunnison County Road 317 to the wooden fence boundary.

Results:

The results of the application of the magnesium chloride on an upper and a lower leaf of Pyrrocoma indicate that there is a damaging effect (Table 1). Almost all of the leaves became chlorotic with brown tips and margins or turned completely yellow. In some instances, the leaves curled and died. The lower leaves ^{exhibited} more severe symptoms than upper leaves. This may be cumulative with other metabolic factors in the plant.

Table 1 Pyrrocoma Treatment Data

Plant	Upper leaves	Lower Leaves
1	Yellow with brown margins	Yellow, curled, dying
2	Yellow with brown margins	Yellow with brown margins
3	Brown	Yellow with brown margins
4	Brown and necrotic	Yellow, brown margins, curled
5	Brown and curled	Yellow, brown margins, curled
6	Yellow with brown margins	Brown and curled

Low
long
effect
application
were the
responses
observed?
were there
repeated
(i.e., multiple)
observations?

what does this mean?

for
low
or
the
go
die
in the
ground
of the
a tree
page
in
for
not
diseased
leaves

In the Heracleum test plants, the results also show damaging effects by the magnesium chloride (Table 2). In addition to the symptoms exhibited by Pyrrocoma, Heracleum exhibited necrosis of the leaves. Also, the lower leaves exhibited more severe symptoms, such as necrosis and dying, than did the upper leaves of the test plants. Again this may be due to other metabolic factors in addition to the application of the magnesium chloride to the leaves.

Table 2 Heracleum Treatment Data

Plant	Upper Leaves	Lower Leaves
1	Yellow, brown margins, necrotic	Yellow, brown margins wilting, necrotic
2	Yellow, brown margins curled, necrotic	yellow and necrotic
3	Yellow with brown tips	Yellow with brown margins curled and necrotic
4	Yellow with brown margins necrotic	Yellow with brown margins
5	necrotic	Yellow with brown margins necrotic, dying
6	Yellow with brown margins necrotic	Yellow with brown margins necrotic, dying

Application of the magnesium chloride to the soil at a prescribed distance from the stems, also ~~exhibited~~ ^{caused} damage to the plants (Table 3). In the Pyrrocoma, the upper leaves began turning brown at the tips, whereas the lower leaves turned yellow. In the Heracleum, the

upper leaves appeared untouched by damage, but the middle leaves were turning yellow and the lower leaves were dying. This is in agreement with the results observed from the leaf application data.

Table 3 Pyrrocoma and Heracleum Soil Treatment Data

Plant	<u>Pyrrocoma</u> Leaves		<u>Heracleum</u> Leaves		
	Upper	Lower	Upper	Middle	Lower
1	OK	Yellow	OK	OK	Yellow
2	Brown Tips	Yellow	OK	Yellow	Dying
3	Brown Tips	Yellow	OK	Yellow	Dying
4	Brown Tips	Yellow	Ok	Yellow	Dying
5	Brown Tips	Necrotic	Ok	Yellow	Yellow
6	Brown Tips	Yellow	Yellow	Necrotic	Dying

~~In Table 1, the control data~~ there is no indication of damage occurring within the control group. From all indications, they are healthy, fully intact, green-leaved plants. The Heracleum plants were also sending out new growth from the roots. One or two of the lower leaves of Heracleum were turning yellow. Obviously, since there was no magnesium chloride applied to any of the plant parts, the conclusion is that this is due to other metabolic factors or age of the leaves.

Table 4 Pyrrocoma and Heracleum Control Data

Plant	<u>Pyrrocoma</u> Leaves		<u>Heracleum</u> Leaves		
	Upper	Lower	Upper	Lower	Shoots
1	OK	OK	OK	Yellow	New
2	OK	OK	OK	OK	New
3	OK	OK	OK	OK	New
4	OK	OK	OK	OK	New
5	OK	OK	OK	Ok	New
6	OK	Ok	Ok	Yellow	New

Discussion:

this is methods! *this is result*

All plants, treated and the controls, were observed daily. Within two days of application of magnesium chloride, effects were becoming evident. The leaves of the treatment plants of both Heracleum and Pyrrocoma, both soil and leaf applications, were becoming chlorotic. This was intriguing because it rained on the plants continuously, beginning only a few hours after of application of the solution. Within four days of application, the tips of the leaves of the treatment plants were turning brown. Still there had only been one day of sunshine; the other three had been rain. At the end of a week, during which it rained five days, leaves were yellow, necrotic in the blades, brown, wilted, curled, or dying. This was observed in both the leaf treatment plants as well as the soil treatment plants.

although some of the plants were in the same container, the results were different. This was due to the fact that the plants were not all of the same age. The older plants were more resistant to the treatment.

the plants were not all of the same age. The older plants were more resistant to the treatment. The results were different. This was due to the fact that the plants were not all of the same age.

It appears that there were also some variables in regard to the severity of damage that was exhibited by the plants. For example, smaller plants exhibited more severe types of damage than larger plants of the same species. The smaller plants, tended to have more yellow, brown, curled, or dying leaves as compared to the larger plants. Effects in the larger plants may have been limited to slight chlorosis or brown tips. Also direct application of the solution to the leaves seemed to cause more severe damage than the soil application to the plants of the same species. Lower, older leaves seemed to sustain more severe damage than the upper, younger leaves in the plants that had the soil applications of solution.

note the fact to support this asser

this is interest if would have many more to make a system of now note diff

In comparison to the treatment plants, the control groups showed greener, healthier leaves. The Pyrocoma control group had very little change. The leaves were bright green with only a tip or two with even a blemish. In the Heracleum control group, there was evidence of some lower, older leaves that had turned yellow, but the upper leaves were a bright green. In addition, there were new shoots growing from the base of the Heracleum control group ^{while} ~~whereas~~ there were none in the treatment group.

It is evident that this concentration of 28% magnesium chloride acts as a defoliant in older, lower leaves when applied to the soil area. It definitely acts as a defoliant when applied directly to the leaves, whether the location is upper or lower on the plant. Also, its effect on smaller susceptible plants is more damaging as compared to larger, well established plants in the same species.

Conclusion:

2 species
In this study of ~~flora~~ along Gunnison County Road 317, it is apparent that the method of salt accumulation control is the category of passive removal. As the salt is absorbed into the leaves, they turn yellow. Then the tips turn brown. Eventually the leaves curl along the margins. Holes appear in the leaves. Then the leaves become brown, wilt, die and are shed from the plant. This is in agreement with Crawley (1997), who stated that one of the ways salt-tolerant plants regulate altered osmotic balance is by ion accumulation in tissue away from active metabolic sites, followed by shedding of these tissues along with their accumulated ions.

Citations:

- ~~Cornell University~~. 1999. MSDS. Magnesium chloride. Msds.pdc.cornell.edu/msds/siri/q309/ 7/4/99
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- ~~Solarchem Resources~~. 1999. Dust-Off. California-Fresno. Fresno, Ca. www.calfreson.com. 7/4/99
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Miscellaneous Tables and Raw Data

Posie - I appreciate your including the raw data. I have several responses relevant to these data. I have
1) I really wish you had consulted w me, or
about analyzing your data. This was a nice idea
well executed study, and it could have been
of appropriate analysis. After all, this is a science con
data demand analysis. If you had described what you
results. 2) It would have been nice if you had "eye-balling" the
column headings. 3) The explanatory
your experimental data. Without such explanation,
are not useful to anyone but you... 4) The documentary
"springline" data set would be most illustrative, perhaps
as a figure - a scatterplot of damage (vertical axis)
independent variables (horizontal axis).
I really appreciate to the
information you did on this project - to find relevant
and report on the internet, to contact the country
it comments I had the opportunity to
variable. On the other hand, I don't
understand why you chose to ex
resulting in me about it. I
included each most to
selected a few

Table I. Damage and Distance from Spray Line for Heracleum sphondylium

Distance	Severe Damage	Mild Damage	No Damage
0.20-0.40 M	15	-	-
0.41-0.60 M	10	-	-
0.61-0.80 M	2	1	-
0.81-1.00 M	1	1	-
1.01-1.20 M	-	-	2
1.21-1.40 M	-	1	2
1.41-1.60 M	-	1	-
1.61-1.80 M	-	1	-
1.81-2.00 M	-	-	-
2.01-4.00 M	-	-	11

The Heracleum stems were measured from the spray line that was still evident on the road. The first stems were contacted at 0.2M from the spray line. An interval of .2M was used to group the data. The first interval was 0.2M-0.4M. The test distance to place the magnesium chloride from the stems was determined to be half-way between the first data group, or a distance of 0.3M.

*the midpoint of the
first distance interval*

Table II. Damage and Distance from Spray Line for Pyrrocoma corocca

Distance	Severe Damage	Mild Damage	No Damage
0.20-0.30 M	9	3	-
0.31-0.50 M	18	7	-
0.51-0.70 M	15	12	2
0.71-0.90 M	8	4	2
0.91-1.10 M	2	11	-
1.11-1.30 M	-	4	1
1.40-3.90 M	-	-	1

The Pyrrocoma stems were measured from the spray line that was still evident on the road. The first stems were contacted at 0.1M from the spray line. An interval of 0.2M was used to group the data. The first interval was 0.10M-0.30 M. The test distance to place the magnesium chloride from the stems was determined to be half way between the first group data, or a distance of 0.2M.

*See previous
comment for
Table I.*

Spray Line Data Collected for Geracleum sphondylium ssp. montanum

0.4 M	severe	yellow					willows
1.3 M	ok						
0.2 M	severe	brown					
0.6 M	severe	brown	necrotic				
0.4 M	severe	yellow	necrotic				
1.0 M	mild	yellow					
0.3 M	severe	yellow	curling				
0.2 M	severe	yellow	curling				
0.7 M	severe	yellow	necrotic	dying			
0.6 M	severe	yellow	necrotic				
1.4 M	mild	brown	necrotic				
1.5 M	mild	spots	curling				
0.6 M	severe	yellow	curling	dying			
0.5 M	severe	yellow	brown	dying			
0.6 M	severe	yellow	brown	dying			
0.4 M	severe	yellow	brown	dying	spray line		
0.3 M	severe	yellow	brown	dying	spray line		
0.4 M	severe	yellow	brown	dying	spray line		
0.4 M	severe	yellow		dying	spray line		
0.3 M	severe	yellow	brown	dying	spray line		
0.5 M	severe	yellow		dying	spray line		
0.5 M	severe	yellow	brown	dying	spray line		
0.4 M	severe	yellow	brown	dying	spray line		
0.3 M	severe	yellow	brown	dying	spray line		
0.8 M	mild	yellow					
0.9 M R	severe	yellow				0.5 M L	
1.3 M R	severe	yellow				0.6 M L	
0.8 M R	severe	yellow				0.3 M L	
0.8 M R	mild	yellow				0.4 M L	willows
1.1 M	ok						
1.1 M	ok						
0.7 M R	severe	yellow				0.4 M L	
0.4 M	severe	yellow	brown	dying			
0.5 M	severe	yellow	brown	dying	spray line		
1.7 M	mild	yellow					
2.1 M	ok						
2.9 M	ok						
3.5 M	ok						
0.9 M	severe	yellow					
3.4 M	ok						
1.3 M	ok						willows
2.7 M	ok						
2.1 M	ok						willows
3.0 M	ok						
3.7 M	ok						
3.9 M	ok						
3.0 M	ok						

Distance. Stems	Damage	Leaves	Leaves	Leaves	Spray line Leaves	Spray line Leaves	Cover
	<u>Heracleum</u>	<u>sphondylium</u>	ssp?	montanum			

Spray Line Dam Collection for Pyrrocoma cinerea

Pyrrocoma crocea						
0.8 M	severe		brown	curling		
0.9 M	severe			curling	dying	
1.1 M	mild		brown tips			
1.0 M	mild		brown tips			
0.8 M	severe				dying	
0.7 M	severe				dying	
1.3 M	mild		brown tips			
.55 M	severe				dying	
.55 M	severe				dying	
1.0 M	severe				dying	
1.5 M	ok					
1.0 M	mild		brown tips			
1.2 M	mild		brown tips			
.95 M	severe		brown tips	curling		
0.6 M	severe		brown tips	curling	dying	
.75 M	severe				dying	small
0.6 M	severe				dying	small
0.6 M	severe				dying	small
0.9 M	severe		brown			
0.9 M	severe		brown			
1.0 M	severe		brown tips	curling		
1.25M	mild	yellow				
1.85M	ok					
.45 M					dying	small
0.7 M	severe		brown tips	curling		
1.0 M	mild	yellow				
1.0 M	mild	yellow	brown tips			
0.8 M	mild	yellow	brown tips			
1.2 M	mild			curling		
1.9 M	ok					
0.5 M	severe		brown		dying	
0.5 M	severe	yellow	brown			
0.5 M	severe	yellow	necrotic	curling		
0.6 M	severe	yellow	necrotic			
0.5 M	severe	yellow	necrotic	curling		
0.4 M	severe				dying	
0.7 M	mild	yellow				
1.1 M	mild	yellow				
1.1 M	mild	yellow				
0.5 M	severe			curling		
0.3 M	severe	yellow	brown tip	curling		
0.3 M	severe	yellow	brown tips	curling		
0.3 M	severe	yellow	brown tips	curling		
0.7 M	mild	yellow				
0.5 M	severe	yellow	brown	curling		
1.1 M	mild					
0.4 M	severe				dying	small

Distance	Damage	Leaves	Leaves	Leaves	Leaves	Plant
Stems						Size

0.6 M	mild	yellow	brown	curling		
0.5 M	mild	yellow	spotted			
0.3 M	severe		brown	curling	dying	
.45 M	mild	yellow				
.18 M	severe	yellow	brown	curling		
.64 M	severe	yellow	brown tips			small
0.3 M	severe	yellow				
0.6 M	mild	yellow				
1.1 M	mild		brown tips			
.58 M	mild	yellow	brown tips			
0.4 M	severe	yellow	brown tips	curling		
.22 M	severe		wilted	curling		
.42 M	severe	yellow	necrotic	curling		
.56 M	ok					small
.19 M	ok					small
.04 M	mild	yellow				small
.06 M	mild	yellow				
.07 M	severe	yellow				
.08 M	mild	yellow				
.35 M	severe	yellow	brown	curling		
.12 M	severe	yellow	brown	curling		
.04 M	mild		brown tips			
.06 M	mild	yellow	necrotic			
.38 M	severe	yellow	brown tips	curling		
.05 M	mild		necrotic			
.06 M	ok					
.07 M	mild	yellow				
.07 M	mild	yellow				
.08 M	ok					
.06 M	mild		necrotic			
.17 M	severe	yellow	brown tips	curling		
.67 M	mild		necrotic			
.75 M	mild	yellow				
.05 M	mild	yellow		curling		
.04 M	mild	yellow	brown tips			
.07 M	mild	yellow				
1.0 M	mild	yellow				
.75 M	severe	yellow	brown tips			
1.1 M	mild	yellow				
.07 M	severe	yellow		curling		
.09 M	severe		brown tips			
.04 M	severe		brown	curling		
.03 M	severe	yellow	brown	curling		
.45 M	severe	yellow			dying	
.04 M	severe	yellow	brown	curling		
.05 M	severe		brown	curling		
.09 M	mild	yellow	necrotic			
.66 M	severe	yellow	brown	curling		
Distance Stems	Damage	Leaves	Leaves	Leaves	Leaves	Plant Size

Pyrrocoma crocea

0.6 M	severe	yellow			
0.35 M	severe		brown tips		dying
0.4 M	severe				dying
0.8 M	severe		brown	curling	
1.2 M	ok				
1.4 M	ok				
1.5 M	ok				
1.9 M	ok				
1.9 M	ok				
2.0 M	ok				
3.2 M	ok				
2.8 M	ok				
2.3 M	ok				
3.9 M	ok				

Distance Stems	Damage	Leaves	Leaves	Leaves	Leaves	Plant Size
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EXPERIMENTAL AND CONTROL GROUP DATA

OF

Heracleum sphondylium ssp montanum and Pyrrocoma crocea

<u>Pyrrocoma</u>		upper	leaves
yellowish	brown	brown	
yellowish	brown		
	brown	brown	
yellowish	brown		necrotic
	brown	brown	curled
yellowish	brown		

color	margin	tips	blade
-------	--------	------	-------

Heracleum

yellowish	brown		necrotic
yellow	brown	curled	necrotic
yellowish		brown	
yellowish	brown	brown	necrotic
		necrotic	
yellowish	brown		necrotic

color	margin	tips	blade
-------	--------	------	-------

<u>Pyrrocoma</u>	Stems	20 cm
------------------	-------	-------

ok	yellowish	large
brown tips		large
brown tips	yellow	small
brown tips	yellow	small
brown tips	necrotic	small
brown tips	yellow	small

upper	lower	size
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<u>Pyrrocoma</u>	Control
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ok	ok
ok	ok
ok	ok
ok	ok
ok	ok
ok	ok

upper	lower
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<u>Pyrrocoma</u>		lower	leaves
yellow	brown	curled	dying
yellow	brown		
yellow			
yellow			
yellow	brown	curled	
	brown	curled	

color	margin	tips	blade
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Heracleum

yellow	brown	wilting	necrotic
yellow			necrotic
yellow	brown	curled	necrotic
yellow	brown		
yellow		necrotic	dying
yellow	brown	necrotic	dying

color	margin	tips	blade
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<u>Heracleum</u>	Stems	30 cm
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ok	ok	yellow	large
ok	yellowish	dying	
ok	yellowish	dying	
ok	yellowish	dying	
ok	yellow	yellow	
yellowish	necrotic	dying	small

upper	middle	lower	size
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<u>Heracleum</u>	Control
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ok	yellowing	new
ok	ok	new
ok	ok	new
ok	ok	new
ok	ok	new
ok	yellowing	new

upper	lower	shoots
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