

Potential for Phytotoxicity of Pendulum 2G
(Pendimethalin) on
Sea Pink (*Armeria maritima* 'Dusseldorf')

By

Heiner Lieth, Director
Linda Dodge
Ron Lane
Dylan Hodgkiss

Project: Interregional Research Project #4
Project Number 24684A – September 30, 2005

Donors/Supporters:
High Ranch Nursery, Loomis, CA

UC Davis Environmental Horticulture IR4 Center
Department of Plant Sciences
University of California
One Shields Ave.
Davis, CA 95616
<http://envhort.ucdavis.edu/ir4>

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Investigator (Name, Address, Phone#, e-mail, etc)	Dr. Heiner Lieth Department of Plant Sciences University of California One Shields Ave. Davis, CA 95616 Ph 530-752-7198 FAX 530-752-1819 Email: jhlieth@ucdavis.edu
Location of Trial	University of California, Davis CA
TRIAL TYPE: (field, container, greenhouse, etc)	Field Container
Chemical - Common Name	Pendimethalin
- Formulation	Granular, 2%
- Batch Number	
- Product	Pendulum 2G
- EPA Registration Number	241-375
- Manufacture	BASF
USE INFORMATION	
- Plant Common Name	Sea Pink, Thrift
- Plant Scientific Name	<i>Armeria maritima</i> 'Dusseldorf'
- Pest (s)	Weeds
Soil Type or Type of Potting Mix: Grower's Mix	a)%Sand: b)%Silt: c)%Clay: d)%OM: e)%pH:
Enter each DATE for:	Seedling: Emergence: Transplanting:
Enter each SPACING for:	Plant or Pot: 6 inches Row: 6 inches
Enter each SIZE for:	Pot: 1-gallon (15 cm) Plot: 50 sq ft
Experimental Design:	Completely randomized design
Number of Reps:	4 reps per treatment

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

APPLICATION PARAMETERS¹

Type of Application: (aerial, ground, foliar, drench, ppi, chemigation, broadcast, directed, etc)	Broadcast over the top
Number of Applications:	2, 30 days apart
Application Type:	Shaker container
Nozzle Type/Size:	
Nozzle Pressure:	
Delivery Rate:	
Calibration Date(s):	

APPLICATION SUMMARY

APPLICATION DATE	RATES (a.i./A) (Be sure to provide units)	Brief Description of Growth Stage (Dormant, New Growth Present, Bud, etc)
August 5, 2005	0, 2, 4, 8 lb. a.i./A	Vegetative and flowering, actively growing
September 2, 2005	0, 2, 4, 8 lb. a.i./A	Vegetative and flowering, actively growing

1 RAINFALL/IRRIGATION RECORDS: INCLUDE RAINFALL/IRRIGATION INFORMATION (printouts, IR-4 forms, etc.)

See Table 1 for environmental conditions. The plants were watered daily with tap water using a drip irrigation system delivering 1 gallon per hour.

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

OTHER PESTICIDES, FERTILIZER, LIME AND ADJUVANTS USED:

PRODUCT	AMOUNT	DATE
Pounce	0.16 oz/2 gal	8/26/2005
Marathon II	2.4 oz/2 gal	8/26/2005

NARRATIVE SUMMARY OF METHODS AND RESULTS:

Materials and Methods

Plant Material and Culture. One-gallon plants of *Armeria maritima* 'Dusseldorf' were received from High Ranch Nursery on July 19, 2005. The plants remained in the 1-gallon pots containing the grower's mix and controlled release fertilizer. The 8-week experiment took place in an outdoor nursery and began on August 5, 2005. Environmental conditions during the experiment are summarized in Table 1. The plants were watered daily during the 8-week experiment with tap water using a drip irrigation system delivering 1 gallon per hour. Applications of pesticides as part of a normal pest management program were made as needed (see above).

Experimental Procedure. 16 plants were randomly chosen and individually tagged for treatment with 0 (Control), 2 (1X), 4 (2X), or 8 (4X) lb. ai/A Pendulum 2G with 4 replicates per treatment. These dosages were prescribed in IR4 Ornamental Protocol 05-001 dated 1/05 (Appendix A). The plants received the first granular application on August 5, 2005 and the second application 4 weeks later on September 2, 2005. The plants were arranged in a completely randomized design with 4 replicates per treatment (Figure 1). Phytotoxicity ratings and plant height and width measurements were taken at day 0, 3, 7, 14, 28, 31, 35, 42 and 56. Visual phytotoxicity evaluations were based on a numerical rating scale ranging from 0 (no injury) to 10 (complete kill) (Table 2). Plant height (cm) was measured from the container soil surface to the top of the canopy.

Plant width (cm) was measured twice along perpendicular lines at the widest part of the plant, resulting in W_1 and W_2 . For each observation a canopy volume index was calculated so as to be able to determine if canopy volume was affected by the application of Pendulum 2G. The calculation was made as $H*W_1*W_2$, where H is the height and W_1 and W_2 are two width measurements. The usefulness of this index is based on the fact that many of the models for such a volume calculation are of the form $a*H*W_1*W_2$. The constant "a" depends on the assumption of the shape of the canopy. Since analyses of variance are scale-independent, the conclusion will thus be for the volume of the plant canopy.

Statistical Analysis. The data were analyzed using Proc GLM of the Statistical Analysis System (SAS). The phytotoxicity and change in mean value from the starting plant height, width and volume index were analyzed for significant differences using t-tests.

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Results

Average phytotoxicity index values of all treatments on all observation dates were below 1.0 and all increases in phytotoxicity index over the initial level were less than 0.75 at any time during the trial in all of the treatments (Table 3, Figure 2, Appendix B).

The *Armeria* plants increased in height between 2.4 and 3.5 cm in the control, 1X and 2X treatments and these mean height increases were not significantly different from each other (Table 4, Figures 2 and 3, Appendix B). The width increased by 5.0 to 6.9 cm in these treatments and these width increases were also not significantly different from each other. The corresponding volume index increases ranged from 3761 to 3535 were also not significantly different from each other. The height, width and canopy volume increased to a significantly lesser extent in the 4X treatment than in the control.

Discussion

Pendulum caused no phytotoxicity on *Armeria* at any of the rates. Pendulum also caused no growth suppression at the 1X and 2X rates. However, the magnitude of the growth reduction due to Pendulum at 4X is significant and growers should be careful to avoid rates as high as 4x or greater.

GOOD RESEARCH PRACTICE STATEMENT:

I acknowledge that I have read and followed the IR-4 Research protocol and completed this trial following good agricultural practice, or reported any deviations (note any changes from authorized protocol in narrative).

SIGNATURE (PRINCIPAL INVESTIGATOR) _____

Date Completed:

If submitted, using e-mail, please provide e-mail address and send confirming receipt.

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Table 1. Environmental conditions during the experiment to evaluate the phytotoxicity of Pendulum 2G on *Armeria maritima* 'Dusseldorf'.

Date	Sol Rad (Ly/day)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Avg Vap (mBars)	Avg wSpd (MPH)	Precip (in)	CIMIS ETo (in)	Avg Rel Hum (%)	Dew Pt (°F)
8/5/2005	658	100.1	58.8	78.2	14.1	3.6	0	0.26	43	53.7
8/6/2005	647	102.6	57	77.7	13.8	4.2	0	0.27	42	53.1
8/7/2005	636	101.3	59.8	78.8	14.2	4	0	0.27	42	53.9
8/8/2005	573	92.2	59.6	73.8	14.9	4.8	0	0.23	52	55.2
8/9/2005	641	99	57.6	75.5	14.8	4.4	0	0.26	49	55.1
8/10/2005	650	94.6	55.8	74.5	14	4.2	0	0.26	48	53.6
8/11/2005	640	97.7	53.2	76	13	3.6	0	0.26	43	51.6
8/12/2005	640	97.6	57.4	75.5	13.8	4.8	0	0.27	46	53.1
8/13/2005	552	81.6	53.7	66.6	13.5	5.7	0	0.2	61	52.6
8/14/2005	613	84.7	54.3	67.1	14.2	5.9	0	0.23	62	53.8
8/15/2005	546	81.1	56.4	69	13.9	6.6	0	0.23	57	53.3
8/16/2005	579	94	62.3	76.1	14.7	4.8	0	0.25	48	54.9
8/17/2005	608	89.8	55.7	70.6	13.7	5.8	0	0.25	54	53
8/18/2005	611	79.8	54.4	65.1	14.1	8.9	0	0.23	67	53.7
8/19/2005	609	83.1	52.7	65.9	13.6	5.9	0	0.22	63	52.8
8/20/2005	608	88.8	51.3	69.7	13.1	3.9	0	0.22	53	51.8
8/21/2005	613	91.9	53.5	71.2	13.5	4.2	0	0.24	52	52.6
8/22/2005	609	95.3	50.1	73.3	13.6	4	0	0.24	48	52.7
8/23/2005	609	95.1	54.7	72.3	13	5.6	0	0.25	48	51.6
8/24/2005	607	89.2	52.9	70.7	12.4	6.9	0	0.26	48	50.2
8/25/2005	601	90.2	53.1	70.8	10.1	4.5	0	0.24	39	44.8
8/26/2005	605	95.2	52.2	73.3	9.6	4.4	0	0.25	34	43.5
8/27/2005	585	97.8	54.5	76.4	11.2	4	0	0.25	36	47.5
8/28/2005	601	98.4	56.8	77	11.2	4.6	0	0.26	35	47.6
8/29/2005	588	90.6	55.5	72.8	11.4	4.2	0	0.23	41	47.9
8/30/2005	587	92.9	65.4	78.3	7.6	11.9	0	0.36	--	--
8/31/2005	580	98.2	59.2	77.1	8.7	4.9	0	0.26	27	40.9
9/1/2005	568	91.7	52.8	71.2	12.4	4.6	0	0.23	47	50.2
9/2/2005	574	87.5	51.9	67.6	12.9	4.8	0	0.21	56	51.4
9/3/2005	568	87.5	50.8	67.2	12.8	5.7	0	0.22	56	51.1
9/4/2005	552	82.5	52	66.2	12.8	5	0	0.19	58	51
9/5/2005	554	87.4	50.2	68.8	11.8	3.5	0	0.2	49	49
9/6/2005	551	86.4	51.4	66.7	11.9	4.9	0	0.21	53	49.2
9/7/2005	544	84.2	48.4	64.6	12.3	4.8	0	0.19	59	50
9/8/2005	536	77.5	50.3	64	12.4	7	0	0.2	61	50.3
9/9/2005	524	73.7	53.5	62.1	12.9	9.6	0	0.19	68	51.2
9/10/2005	481	76.4	49.9	62	11.7	5.6	0	0.17	62	48.8
9/11/2005	531	76.2	45.3	61.4	11.1	4.1	0	0.17	60	47.3
9/12/2005	520	78.2	44	61.3	10.7	2.3	0	0.16	58	46.3
9/13/2005	521	78.5	42.8	60.6	10.7	4	0	0.17	59	46.4
9/14/2005	505	76.3	46.7	60.6	11.9	4.5	0	0.16	66	49.1
9/15/2005	506	81.1	46.3	62.6	11.8	3.5	0	0.16	61	48.9
9/16/2005	491	79.9	52.2	63.6	12.2	6.9	0	0.18	61	49.7
9/17/2005	486	78.1	48.7	63.4	11.9	4.4	0	0.17	60	49.1
9/18/2005	491	83.8	46.2	65.7	9.5	3.7	0	0.18	44	43.3
9/19/2005	495	89.7	46.9	68.1	9.3	3.5	0	0.19	39	42.5
9/20/2005	458	89.6	51.4	70.3	10.5	6.2	0	0.2	42	45.8
9/21/2005	464	86.5	54.6	67.8	12.4	4.3	0	0.17	54	50.3
9/22/2005	492	87.1	48.2	66.1	10.8	4	0	0.18	49	46.5
9/23/2005	480	80.1	53.1	65.7	9.8	9.1	0	0.23	45	44.1
9/24/2005	479	78.5	56.2	66.6	5.9	10.1	0	0.26	27	31.3
9/25/2005	460	82.3	52.3	66.2	6.5	5.9	0	0.2	29	33.4
9/26/2005	400	86.6	55.3	70	9.8	4.7	0	0.18	39	43.9
9/27/2005	441	84.8	52.1	68.5	11.7	2.7	0	0.16	49	48.7
9/28/2005	463	94.1	58.6	74.6	9.1	6.4	0	0.23	31	42
9/29/2005	451	92.4	49.6	70.8	10	2.9	0	0.17	39	44.5
9/30/2005	438	92.2	52.8	71	10.5	3.4	0	0.17	40	45.8

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Table 2. Numerical plant damage rating scale used for phytotoxicity determinations.

Rating	Description of plant damage
0	No damage
1	No visible damage but unintended (non-permanent) impact
2	Slight leaf/tissue damage (curling leaves, necrosis, etc.)
3	Marginal chlorosis on some leaves (damage on up to 10% of plant)
4	10% – 20% of plant damaged
5	Significant damage to much of plant (30% - 40%)
6	40% – 60% of plant damaged
7	Chlorosis or necrosis on most of plant (60% - 70%)
8	Abscised leaves, branch dieback
9	Tissue severely damaged (80% - 100% of plant)
10	Complete kill

Table 3. Phytotoxicity ratings over 8 weeks for *Armeria maritima* ‘Dusseldorf’ treated with 0 (Control), 2 (1X), 4 (2X), or 8 (4X) lb. ai/A Pendulum 2G, applied at weeks 0 and 4. Different letters within a column indicate significant differences between treatments (P < 0.05). “Yes”/”No” refer to significant treatment effects at the 5% level. Means ± SE (n = 4)

Phytotoxicity Effect of Pendulum on Armeria								
Phytotoxicity Index Increase from beginning of trial until:								
Treatment	Day 3	yes	1 week	yes at 10%	2 weeks	no	4 weeks	no
0X	0.00 ± 0.00	a	0.00 ± 0.00	b	0.25 ± 0.25	a	0.50 ± 0.29	a
1X	0.00 ± 0.00	a	0.00 ± 0.00	b	0.25 ± 0.25	a	0.25 ± 0.25	a
2X	0.00 ± 0.00	a	0.00 ± 0.00	b	0.00 ± 0.00	a	0.50 ± 0.29	a
4X	0.00 ± 0.00	a	0.50 ± 0.29	a	0.25 ± 0.25	a	0.75 ± 0.25	a
Phytotoxicity Index increase from beginning of trial until:								
Treatment			5 week	no	6 weeks	no	8 weeks	no
0X			0.00 ± 0.41	a	-0.25 ± 0.25	a	-0.50 ± 0.29	a
1X			-0.25 ± 0.25	a	-0.25 ± 0.25	a	-0.25 ± 0.25	a
2X			0.00 ± 0.00	a	-0.25 ± 0.25	a	-0.25 ± 0.25	a
4X			0.25 ± 0.25	a	0.25 ± 0.25	a	-0.25 ± 0.25	a

Table 4. Plant height, width and volume changes over 8 weeks for *Armeria maritima* ‘Dusseldorf’ treated with 0 (Control), 2 (1X), 4 (2X), or 8 (4X) lb. ai/A Pendulum 2G, applied at weeks 0 and 4. Different letters within a column indicate significant differences between treatments (P < 0.05). “Yes”/”No” refer to significant treatment effects at the 5% level. Means ± SE (n = 4)

Growth Effect of Pendulum on Armeria						
Increase by week 8 of:						
Treatment	Height (cm)	yes at 10%	Average Width (cm)	yes at 10%	Volume Index	yes
0X	2.38 ± 0.38	ab	6.94 ± 1.29	a	3719.00 ± 357.55	a
1X	3.38 ± 0.69	a	6.00 ± 0.57	ab	3761.50 ± 204.48	a
2X	3.50 ± 0.65	a	5.00 ± 0.37	ab	3535.38 ± 137.54	a
4X	1.50 ± 0.35	b	3.38 ± 1.02	b	2179.13 ± 178.91	b

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM



Figure 1. *Armeria maritima* 'Dusseldorf' plants were arranged in a completely randomized design with 4 replicates per treatment for the experiment to evaluate the phytotoxicity of Pendulum 2G.

PR.NO.	24684
:	
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Species: *Armeria* -- Material: Pendulum

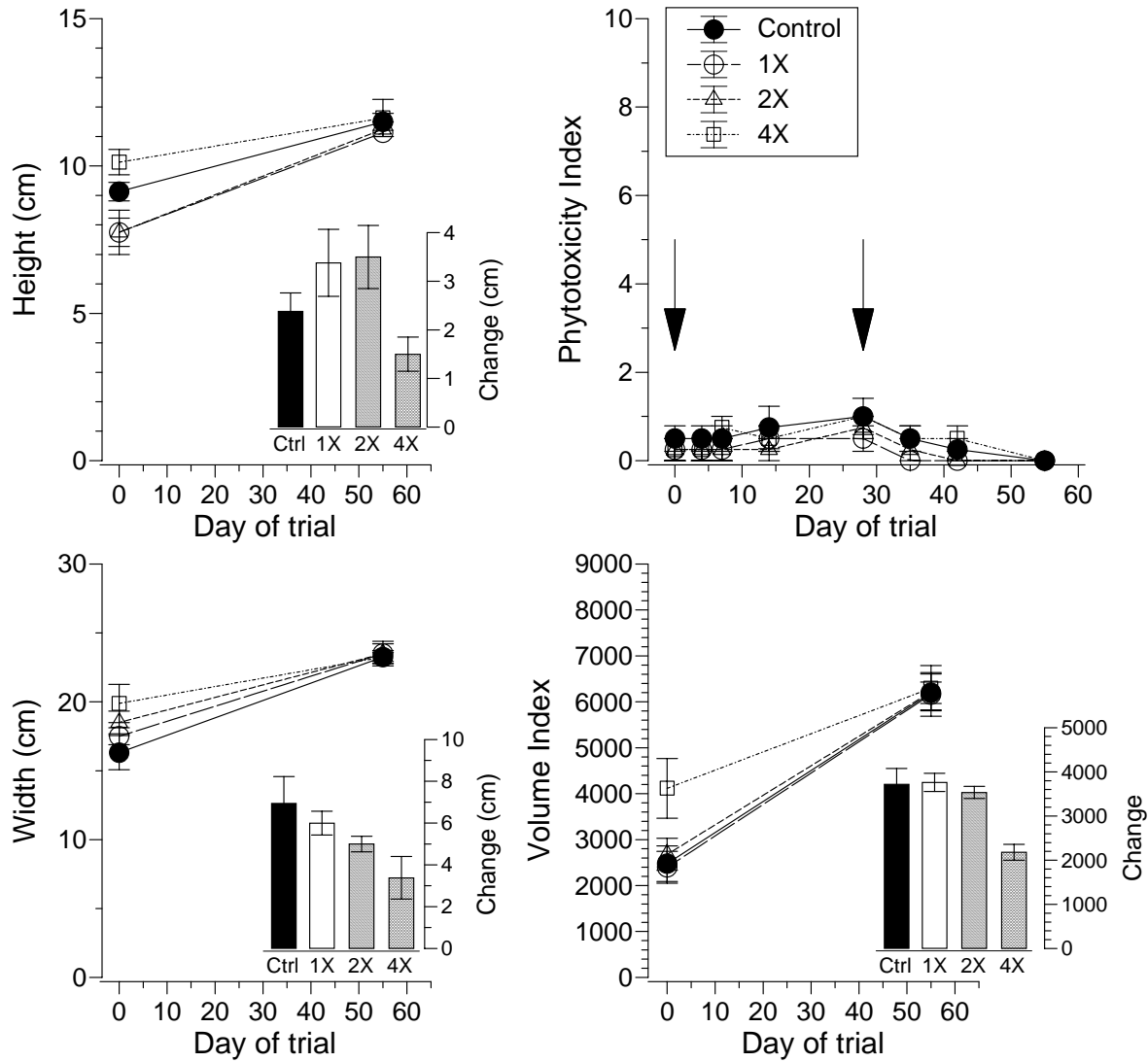


Figure 2. Summary of results for *Armeria maritima* 'Dusseldorf' treated with 0 (Control), 2 (1X), 4 (2X), or 8 (4X) lb. ai/A Pendulum 2G, applied at weeks 0 and 4 (arrows). Both means and cumulative changes over time are plotted for phytotoxicity index, plant height, plant width and plant volume index. Histograms show changes over the 8-week trial period. SE bars shown. (n = 4)

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM



CONTROL

1X

2X

4X

Figure 3. *Armeria maritima* 'Dusseldorf' plants 8 weeks after treatment with 0 (Control), 2 (1X), 4 (2X), or 8 (4X) lb. ai/A Pendulum 2G, applied at weeks 0 and 4.

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Appendix A

Phytotoxicity to herbaceous perennial plants with pre-emergent applications of Pendulum, Pennant Magnum, and Snapshot

Ornamental Protocol Number: 05-001

Objective: Determine phytotoxicity of Pendulum, Pennant Magnum, and Snapshot to unlabelled perennial plants commonly grown in nurseries.

Experimental Design:

Plot Size: Must be adequate to reflect actual use conditions.

Replicates: Minimum of 3 replications (preferably 4) with 3 pots per replicate

Application Instructions: Two applications made approximately 4 weeks apart with the first application within 7 days of potting. Plant materials must have broken dormancy prior to first application. For liquid applications, use a minimum of 20 gal per acre. Applications should be made over the top of the plants using application equipment consistent with conventional commercial equipment. Please see table below for instructions for post-application irrigation.

Plant Materials: See attached list of plant materials. Plants grown in field containers are preferred to in-ground.

Evaluations: Record phytotoxicity on a scale of 0 to 10 (0 = No phytotoxicity; 10 = Complete kill) at 3, 7, 14, and 28 days after each application. If phytotoxicity is observed in treated plants, take pictures comparing treated and untreated plant material.

Recordkeeping: Keep detailed records of weather conditions including temperature and precipitation, soil-type or soil-less media, application equipment, application volume per acre, irrigation, liner size, plant height & width, and plant growth stage at application and data collection dates.

Treatments:

Product	Rate	Post-Application Irrigation Instructions
Pendulum 2G (pendimethalin)	2.0 lb ai/A	Follow with sufficient overhead irrigation to wash Pendulum from the foliage to reduce the chance of injury
	4.0 lb ai/A	
	8.0 lb ai/A	
Pennant MAGNUM 7.62EC (s-metalochlor)	2.5 lb ai/A	Follow with sufficient overhead irrigation to wash Pennant Magnum from the foliage to reduce the chance of injury
	5.0 lb ai/A	
	10.0 lb ai/A	
Snapshot 2.5TG (isoxaben+trifluralin)	2.5 lb ai/A	Follow with sufficient overhead irrigation to wash Snapshot from the foliage to reduce the chance of injury
	5.0 lb ai/A	
	10.0 lb ai/A	
Untreated	--	--

For labels, materials, and any required adjuvants contact:

Pendulum - BASF, Kathie Kalmowitz, 919-785-9659, email: kalmowk@basf-corp.com
 Pennant Magnum - Syngenta, Dave Ross, 336-632-6411, david.ross@syngenta.com
 Snapshot - Dow AgroSciences, Mike Melichar, 317-337-4982, mwmelichar@dow.com

Reports:

Report must include a brief summary paragraph of results, a summary table with appropriate statistical analyses, a section on experimental design and materials and methods, with raw data and recordkeeping information as listed above included as appendices. If pictures were taken, please include them.

An electronic report is preferred but not required. If the report is provided electronically, the basic report can be sent in MS Word or WordPerfect, the recordkeeping information as pdf or other electronic documents, and the raw data in MS Excel or other suitable program such as ARM.

Please direct questions to: Cristi Palmer, IR-4 HQ, Rutgers University, 681 US Hwy 1 S, North Brunswick, NJ 08902-3390, Phone 732-932-9575 x629, palmer@aesop.rutgers.edu OR Ely Vea, 308 Aston Forest Lane, Crownsville, MD 21032, Phone & FAX#: 410-923-488, E-mail: evvea@comcast.net.

PR.NO. :	24684
TRIAL:	
DATE:	9/30/05

IR-4 ORNAMENTAL DATA REPORTING FORM

Appendix B

Phytotoxicity Report Form for Pendulum on Armeria																	
Treatment	Block	Rep	Phytotoxicity at week									Plant Size at week 0			Plant Size at week 8		
			day				day					Height (cm)	Width1 (cm)	Width 2 (cm)	Height (cm)	Width1 (cm)	Width 2 (cm)
			0	3	1	2	4	3	5	6	8						
Control	0	1	0	0	0	0	0	0	0	0	0	10	19	17	12	26	22
Control	0	2	1	1	1	1	1	0	0	0	0	9	12	13.5	11	24	23
Control	0	3	0	0	0	0	1	0	1	0	0	9	19	17	11	25	21
Control	0	4	1	1	1	2	2	0	1	1	0	8.5	17	16	12	23	22
Mean			0.5	0.5	0.5	0.8	1.0	0.0	0.5	0.3	0.0	9.1	16.8	15.9	11.5	24.5	22.0
1X	0	1	1	1	1	1	1	0	0	0	0	6	16.5	17	11	23	22
1X	0	2	0	0	0	1	0	0	0	0	0	9	16	17	11.5	25	22
1X	0	3	0	0	0	0	1	0	0	0	0	7	17	18	11	23	21
1X	0	4	0	0	0	0	0	0	0	0	0	9	18	20.5	11	26	26
Mean			0.3	0.3	0.3	0.5	0.5	0.0	0.0	0.0	0.0	7.8	16.9	18.1	11.1	24.3	22.8
2X	0	1	0	0	0	0	1	0	0	0	0	8	17.5	16	11	23	22
2X	0	2	1	1	1	1	1	0	1	0	0	7	17	18	11	23	22
2X	0	3	0	0	0	0	1	0	0	0	0	7	19	20	12	25	22
2X	0	4	0	0	0	0	0	0	0	0	0	9	21.5	19	11	27	24
Mean			0.3	0.3	0.3	0.3	0.8	0.0	0.3	0.0	0.0	7.8	18.8	18.3	11.3	24.5	22.5
4X	0	1	0	0	0	0	1	0	0	0	0	11	22	21	12	26	22
4X	0	2	0	0	1	0	1	0	0	0	0	10	21	20.5	11.5	24	24
4X	0	3	1	1	1	1	1	0	1	1	0	9	16.5	15	10	23	21
4X	0	4	0	0	1	1	1	0	1	1	0	10.5	21	22	13	24	22
Mean			0.3	0.3	0.8	0.5	1.0	0.0	0.5	0.5	0.0	10.1	20.1	19.6	11.6	24.3	22.3