# Dimethenamid Persistence and Leaching Potential in a Soilless Mix[1]

**Lori Robertson and Jeffrey F. Derr[2]**

## Abstract

Dimethenamid and the granular combination product pendimethalin plus dimethenamid are herbicides registered for use in nursery production and landscape maintenance. The objectives of this study were: (1) to compare the effectiveness of sprayed dimethenamid and the granular combination of pendimethalin plus dimethenamid in container nursery production, (2) to determine the impact of formulation on leaching of dimethenamid in soilless media versus field soil and (3) to determine the influence of irrigation volume on herbicide leaching. Dimethenamid is less mobile in pine bark than field soil, while pendimethalin is more mobile in pine bark. The leaching profile for the granular pendimethalin plus dimethenamid combination product was similar to dimethenamid in field soil and similar to pendimethalin in pine bark. There was no significant difference in herbicide movement in pine bark or field soil after doubling the irrigation volume from 17.8 cm (7 in) to 35.6 cm (14 in). Compared to pendimethalin, dimethenamid leaches less in pine bark, explaining its greater effectiveness for weed control in container production.

**Index words:** Herbicide leaching, soilless mix, pine bark, ornamentals, adsorption.

**Species used in this study:** southern crabgrass [*Digitaria ciliaris (Retz.) Koel.];* spotted spurge *[Chamaesyce maculata (L.) Small]*.

**Chemicals used in this study:** dimethenamid (Tower); dimethenamid plus pendimethalin (FreeHand); pendimethalin (Pendulum 2G).

### Significance to the Horticulture Industry

Weed control is an important management concern in container nursery production. An important way weeds are controlled is through the use of preemergence herbicides. Dimethenamid was more effective for southern crabgrass and spotted spurge control than pendimethalin. The effectiveness of preemergence herbicides is dependent on the amount of leaching that occurs. A sprayable formulation of dimethenamid exhibited less leaching than a granular form of pendimethalin in a pine bark substrate. The low level of leaching for dimethenamid explains the effectiveness of this herbicide for weed control in containers.

### Introduction

The nursery industry in Virginia is a $1.2 billion industry (USDA 2010). Soilless mixes are the primary substrate used in container nursery production in the eastern United States, with pine bark being the dominate component. Fertilizer application plus frequent inputs of irrigation create an excellent environment for weed growth. Weed control is one of the most costly aspect of container production (Norcini and Stamps 1992). Preemergence herbicides are commonly used, but there are concerns about root injury in shrubs and ornamental grasses from certain preemergence herbicides (Briggs and Whitwell 2002, Derr and Salihu 1996, Hayes et al. 1999, Thetford and Gilliam 1991). Derr and Simmons (2006) found significant root reduction in azaleas treated with pendimethalin. Further investigation into pendimethalin formulations found that the microencapsulated form has a greater potential for leaching than the emulsifiable concentrate formulation (Derr et al. 2014). Dimethenamid is a more recent option for use in container nursery production. The objectives of this study were to compare the effectiveness of dimethenamid for weed control in pine bark compared to field soil, evaluate dimethenamid leaching potential in pine bark compared to field soil under different irrigation volumes, as well to determine the impact of formulation on dimethenamid leaching compared to that seen with pendimethalin.

### Materials and Methods

*Southern crabgrass and spotted spurge control.* Plastic 4L (1 gal) pots were filled with either 100% loblolly pine (*Pinus taeda* L.) bark or with 100% field soil [Tetotum loam (fine-loamy, mixed, thermic Hapludults)], then seeded with southern crabgrass or spotted spurge at 0.6 ml (1/8 tsp) per three pots. The emulsifiable concentrate formulation of dimethenamid and a 2% granular form of pendimethalin were applied at 1.7 kg active ingredient (a.i.)·ha$^{-1}$ (1.5 lb a.i.·A$^{-1}$) and 3.4 kg a.i.·ha$^{-1}$ (3.0 lb a.i.·A$^{-1}$), respectively, and a granular combination product of dimethenamid plus pendimethalin was applied at 3.9 kg a.i.·ha$^{-1}$ (3.5 lb a.i.·A$^{-1}$), and compared to nontreated pots of 100% pine bark and 100% field soil. These products are commonly used to control southern crabgrass and spotted spurge, common weeds found in container nursery production. Pots were fertilized with a slow-release product (Osmocote 15-9-12, Everris International B.V., P.O. Box 40, 4190 CA Geldermalsen, The Netherlands) at 10 g (0.3 oz) per pot. Southern crabgrass and spotted spurge stand was recorded 14 days after treatment (DAT).

[1]Received for publication April 11, 2017; in revised form October 25, 2017.

[2]Research Assistant and Professor, Dept. Plant Pathol., Physiol., and Weed Sci., Virginia Tech, Hampton Roads Ag. Res. & Ext. Center, 1444 Diamond Springs Rd., Virginia Beach, VA 23455. Corresponding author: jderr@vt.edu.

  

**Table 1. Southern crabgrass and spotted spurge stand 14 DAT with three preemergence herbicides in field soil and pine bark in containers.**

| | | Number per pot | | | |
|---|---|---|---|---|---|
| | | Southern crabgrass | | Spotted spurge | |
| Herbicide | Rate Kg·ha$^{-1}$ | Field soil | Pine bark | Field soil | Pine bark |
| Nontreated | 0 | 23.6 | 35.9 | 19.2 | 25.5 |
| Dimethenamid | 1.7 | 1.9 | 0.1 | 0.4 | 0.4 |
| Dimethenamid + pendimethalin | 3.9 | 0.8 | 2.5 | 0.1 | 1.9 |
| Pendimethalin | 3.7 | 0.1 | 18.5 | 0.6 | 8.5 |
| LSD[z] | | 6.2 | 4.7 | 6.3 | 4.8 |

[z]Least significant difference values compare across herbicides within a given media based on Fisher's Protected LSD test (P = 0.05).

*Leaching columns general conditions.* The following three experiments were conducting using the same field soil and pine bark as for the southern crabgrass control study. Soil leaching columns were constructed from 35 cm-long (14 in) sections of polyvinyl chloride pipe with an internal diameter of 5 cm (2 in). The ends were sealed with threaded caps, and 0.6 cm tubing was used in the center of each cap for drainage. Landscape fabric was placed at the bottom of each end cap. Construction sand was packed in the bottom 4 cm (1.6 in) of each column. The columns were then uniformly packed with 24 cm (9 in) of pine bark or field soil. Columns were filled with 15 cm (6 in) of air-dried growing medium, and tapped on a hard surface 30 times. This was repeated until a total of 24 cm of growing medium was uniformly packed into each column. The columns were saturated with water and allowed to drain for 24 h, at which time the downward movement of water had ceased. Surfaces of the pine bark or field soil were treated with an emulsifiable concentrate form of dimethenamid at 1.7 kg a.i.·ha$^{-1}$, a granular form of pendimethalin at 3.4 kg a.i.·ha$^{-1}$, or a granular form of the dimethenamid plus pendimethalin combination product at 3.9 kg a.i.·ha$^{-1}$; these treatments were compared to a nontreated control. After the last irrigation, the columns were allowed to drain for 24 h. The pine bark or field soil was plunged out in sections into an aluminum dish and then transferred into a 3.8-cm-diam (1.5 in) pot. Sections were as followed: 0 to 3 cm (0 to 1.2 in), 3 to 6 cm (1.2 to 2.4 in), 6 to 9 cm (2.4 to 3.5 in), 9 to 12 cm (3.5 to 4.7 in), 12 to 18 cm (4.7 to 7.1 in), and 18 to 24 cm (7.1 to 9.4 in) from the surface. Each pot was planted with a 0.6 ml of southern crabgrass seed as a bioassay. Ten plants were randomly selected. Growing medium was removed by rinsing the roots in water, with manual removal of large pine bark particles. Plants were blotted with a cloth and root lengths were recorded. Shoot and root were separated and total fresh weights of all 10 plants were recorded. Percent control was calculated by comparing southern crabgrass root weight and root length in treated columns to that in nontreated columns.

These experiments were conducted under greenhouse conditions, with an average high temperature of 28 C (82 F) and a low of 14 C (57 F). A randomized complete block experiment design was used and the experiment was repeated three times. Data was subjected to analysis of variance, with mean separation using Fisher's LSD (P = 0.05). A student's t test (P = 0.05) was used to compare southern crabgrass root weight and root length between media within a specific depth.

*Leaching in pine bark compared to field soil at 17.8 cm (7 in) of irrigation.* Soil columns were filled with pine bark and field soil. After 15 minutes, each column was irrigated with 20 ml of water. Water was applied with a buret at 2.5 cm (1 in) per column every day for 7 d after herbicide application. The water was applied at a rate of 52 ml (1.8 fl oz) in 15 min per column. As described previously, the columns were allowed to drain and depths separated and seeded.

*Leaching in pine bark compared to field soil at 35.6 cm (14 in) of irrigation.* This experiment was identical to the previous experiment, except irrigation volume was doubled. Irrigation water was applied with a buret at 2.5 cm (1 in) per column every day for 14 days.

*Leaching in pine bark compared to field soil at 2.5 cm (1 in) of irrigation*. This experiment was identical to the 17.8 and 35.6 cm irrigation studies except the total irrigation volume was 2.5 cm. The irrigation application consisted of one 2.5 cm (1 in) application.

## Results and Discussion

*Southern crabgrass and spotted spurge control.* All three herbicides provided excellent control of both weed species in field soil (Table 1). In pine bark, however, dimethenamid and dimethenamid plus pendimethalin gave greater control of southern crabgrass and spotted spurge than pendimethalin. Dimethenamid behaves differently than pendimethalin in pine bark.

*Leaching in pine bark compared to field soil with 17.8 or 35.6 cm irrigation.* No significant difference was found between 17.8 cm and 35.6 cm of irrigation water, thus the data was combined (Table 2). Southern crabgrass root lengths and weights indicated dimethenamid did not leach below the upper 0 to 3 cm depth in pine bark. However in field soil, dimethenamid leached throughout the entire column as it reduced southern crabgrass root length and weight at all depths, including the 18 to 24 cm depth. Conversely, pendimethalin only caused a significant reduction in southern crabgrass root length and weight in the 0 to 3 cm zone of field soil but reduced root length by 46% in the 3 to 6 cm depth for pine bark. The dimethenamid plus pendimethalin combination product showed similar results compared to dimethenamid alone in field soil, with similar results to pendimethalin in pine bark. Since dimethenamid alone leached throughout the field soil column, it likely caused the same effect for the dimethenamid plus pendimethalin product. Since pendimethalin applied alone leached into the 3 to 6 cm depth in pine bark, it likely caused the same effect for the dimethenamid plus pendimethalin product. The combination product also showed greater leaching in pine bark than dimethenamid alone, which is explained by the greater leaching of pendimethalin compared to dimethenamid in pine bark.

**Table 2. Movement of dimethenamid, pendimethalin, and dimethenamid plus pendimethalin in field soil and pine bark, as indicated by southern crabgrass root length and root weight as a percent of the nontreated, averaged over the 17.8 and 35.6 cm irrigation levels.**

| | | Root length | | | Root weight | | |
|---|---|---|---|---|---|---|---|
| Media | Depth cm | Dimethenamid | Pendimethalin | Dimethenamid + pendimethalin | Dimethenamid | Pendimethalin | Dimethenamid + pendimethalin |
| Field soil | 0-3 | 51 | 4 | 19 | 59 | 7[a] | 23 |
| | 3-6 | 49[az] | 86[a] | 39 | 53[a] | 71 | 45 |
| | 6-9 | 49[a] | 87 | 48[a] | 50[a] | 65 | 54[a] |
| | 9-12 | 48[a] | 102 | 62[a] | 47[a] | 110 | 60[a] |
| | 12-18 | 47[a] | 103 | 64[a] | 43[a] | 95 | 62[a] |
| | 18-24 | 42[a] | 99 | 76 | 37[a] | 102 | 75 |
| | LSD[y] | 17 | 18 | 18 | 33 | 36 | 28 |
| Pine bark | 0-3 | 23 | 13 | 14 | 31 | 20 | 8 |
| | 3-6 | 89 | 54 | 53 | 76 | 49 | 59 |
| | 6-9 | 92 | 82 | 95 | 89 | 78 | 91 |
| | 9-12 | 83 | 100 | 96 | 82 | 91 | 86 |
| | 12-18 | 92 | 97 | 96 | 85 | 92 | 97 |
| | 18-24 | 88 | 95 | 102 | 91 | 95 | 90 |
| | LSD[y] | 10 | 16 | 19 | 22 | 18 | 30 |

[z]Indicates a significant difference between media within a giving depth and treatment based on Student's t test (P = 0.05).

[y]Least significant difference values compare across herbicides within a given media based on Fisher's Protected LSD test (P = 0.05).

These studies demonstrate that dimethenamid is more mobile in field soil than in pine bark. The low leaching of dimethenamid in pine bark correlates with the effective control of southern crabgrass and spotted spurge with this herbicide (Table 1).

*Leaching in pine bark compared to field soil with 2.54 cm irrigation.* Based on southern crabgrass root length and weight, dimethenamid leached into the 6 to 9 cm depth in field soil but did not leach below the 0 to 3 cm depth in pine bark (Table 3). Root length in the 3 to 6 cm depth for dimethenamid alone and pendimethalin alone for field soil were 59% and 89% of the nontreated control, respectively, while in pine bark, root lengths were 109% and 78% of the nontreated control respectively. The effect of dimethenamid plus pendimethalin was similar to dimethenamid alone in field soil, and similar to that seen with pendimethalin alone in pine bark, consistent with the results seen in Table 2. Dimethenamid did not leach as deeply after 2.5 cm of irrigation (Table 3) compared to that seen after 17.8 or 35.6 cm of irrigation (Table 2), as expected. This experiment shows that dimethenamid can leach in field soil after only a single 2.5 cm irrigation.

Dimethenamid leached considerably in field soil, but not in pine bark, while pendimethalin leached more in pine bark than field soil. In general, pesticide adsorption is strongly correlated to their octanol-water partition coefficient and negatively correlated to their water solubility (Barriuso et al. 1992) Water solubility for dimethenamid and pendimethalin are 1,174 ppm and 0.275 ppm respectively (Table 4), suggesting dimethenamid has a greater leaching potential. The field soil matrix has closely packed particles and considerably less volume of void space than pine bark, which accounts for pine bark's greater drainage, and less water holding capacity than field

**Table 3. Movement of dimethenamid, pendimethalin, and dimethenamid plus pendimethalin in field soil and pine bark, as indicated by % of control Southern crabgrass root length and root weight after 2.54 cm of irrigation.**

| | | Root length | | | Root weight | | |
|---|---|---|---|---|---|---|---|
| Media | Depth cm | Dimethenamid | Pendimethalin | Dimethenamid + pendimethalin | Dimethenamid | Pendimethalin | Dimethenamid + pendimethalin |
| Field soil | 0-3 | 13 | 1 | 7[a] | 8 | 2 | 4 |
| | 3-6 | 59[az] | 89 | 59 | 54 | 84 | 47 |
| | 6-9 | 73 | 89 | 84 | 78 | 91 | 86 |
| | 9-12 | 87 | 91 | 94 | 93 | 90 | 99 |
| | 12-18 | 87 | 94 | 95 | 80 | 95 | 104 |
| | 18-24 | 80 | 82 | 100 | 91 | 96 | 98 |
| | LSD[y] | 29 | 19 | 25 | 25 | 16 | 26 |
| Pine bark | 0-3 | 9 | 8 | 10 | 3 | 13 | 9 |
| | 3-6 | 109 | 78 | 83 | 107 | 76 | 88 |
| | 6-9 | 112 | 109 | 110 | 89 | 101 | 100 |
| | 9-12 | 107 | 109 | 106 | 102 | 105 | 93 |
| | 12-18 | 101 | 102 | 99 | 103 | 97 | 94 |
| | 18-24 | 98 | 108 | 107 | 98 | 97 | 97 |
| | LSD[y] | 20 | 17 | 23 | 24 | 19 | 20 |

[z]Indicates a significant difference between media within a giving depth and treatment based on Student's t test (P = 0.05).

[y]Least significant difference values compare across herbicides within a given media based on Fisher's Protected LSD test (P = 0.05).

**Table 4. Properties for dimethenamid and pendimethalin, taken from Senseman, S.A., Ed. 2007. Herbicide Handbook, 9th ed. Weed Sci. Soc. Am. Lawrence, Kansas. p. 262, 263, 283, 284.**

| Herbicide | Solubility in water $mg \cdot L^{-1}$ | Koc $mg \cdot L^{-1}$ | ½ life days |
|---|---|---|---|
| Dimethenamid-P | 1,174 | 2.4 | 20 |
| Pendimethalin | 0.275 | 29,000 | 44 |

soil. One would expect dimethenamid to have the same or greater leaching in pine bark compared to field soil. Analysis of the Tetotum loam field soil showed an organic matter content of 3.2% and a cation exchange capacity (CEC) of 4.42 $cmol \cdot kg^{-1}$; for the pine bark used, it had an organic matter content of 63.5% and a CEC of 39.3 $cmol \cdot kg^{-1}$ (Simmons and Derr 2007). Since dimethenamid leaches less in pine bark, which has a higher organic matter percentage, this suggests dimethenamid has a preference for the organic matter binding sites in pine bark. Westra (2015) reported similar findings; he compared 25 different soil textures and herbicide sorption to organic matter. The person correlation between the sorption coefficient Kd value for dimethenamid was 0.917 for organic matter but 0.064 for clay, and dimethenamid Koc values for organic matter and clay were 0.512 and 0.040 respectively, further supporting dimethenamid preference for organic matter sorption sites over clay. It is obvious that these sites are not present in significant quantities in field soil.

Dimethenamid and the dimethenamid plus pendimethalin combination product provided excellent control of southern crabgrass and spotted spurge in a pine bark growing medium. The excellent weed control seen with dimethenamid in soilless mix is due to low leaching of this herbicide in pine bark, even after 35.6 cm (14 in) of irrigation. Dimethenamid provides greater weed control than pendimethalin in pine bark, most likely due to greater leaching of pendimethalin than dimethenamid.

## Literature Cited


Barriuso, E., U. Baer, and R. Calvet. 1992. Dissolved organic matter and sorption-desorption of dimefuron, atrazine and carbetamide by soils. J. Environ. Qual. 21: 359–367.

Briggs, J., and T. Whitwell. 2002. Effect of prodiamine formulation on injury to ornamentals. Pages 384-388 in Proc. South. Nur. Assoc. Res. Conf. 47:384–388.

Derr J.F. and L.D. Simmons. 2006. Pendimethalin influence on azalea shoot and root growth. J. Environ. Hort. 24:221–225.

Derr, J.F., L. Robertson, and E. Watson. 2015. Leaching behavior of two pendimethalin formulations in a soilless growing medium. Weed Sci. 63(2):555–560.

Derr, J.F. and S. Salihu. 1996. Preemergence herbicide effects on nursery crop root and shoot growth. J. Environ. Hort. 14: 210–213.

Hayes, C. K., C.H. Gilliam, G.J. Keever, and D.J. Eakes. 1999. Effects of herbicide and time of application on pampas grass grown in containers. J. Environ. Hort. 17: 185–189.

Gillespie, W.E., G.F. Czapar, and A.G. Hager. 2011. Pesticide fate in the environment: a guide for field inspectors. http://www.isws.uiuc.edu/pubdoc/CR/ISWSCR2011-07.pdf. Accessed April 4, 2017.

Norcini, J.G. and R.H. Stamps. 1994. Container nursery weed control. Circular 678, Florida Coop. Ext. Ser., Inst. Food and Ag. Sci., Univ. Florida, Gainesville, FL. 11 p.

Senseman, S.A., Ed. 2007. Herbicide Handbook, 9th ed. Weed Sci. Soc. Am. Lawrence, Kansas. p. 262, 263, 283, 284.

Simmons, L.D. and J.F. Derr. 2007. Pendimethalin movement through pine bark compared to field soil. Weed Technol. 21(4): 873–876.

Thetford, M. and C.H. Gilliam. 1991. Herbicide use in propagation: effects on rooting and root growth of stem cuttings. J. Environ. Hort. 9: 21–23.

USDA (2007) Census Publication: Virginia Green Industry Survey: 2010 and 2002.

Westra, E.P., D.L. Shaner, K.A. Barbarick, and R. Khosla. 2015. Evaluation of sorption coefficients for pyroxasulfone, *s*-metolachlor, and dimethenamid-*p*. Air Soil and Water Research 8:9–15.