Herbicide Adsorption and Release Properties of Five Oxadiazon-Coated Fertilizers[1]

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Abstract

Laboratory experiments were conducted to determine the release of oxadiazon coated on control-release fertilizers. Five fertilizers and glass beads (nonabsorbent control) were coated with ^{14}C-oxadiazon + formulated oxadiazon at a herbicide-to-fertilizer concentration of 0.3 mg ai/g. Coated fertilizers were subjected to 14 consecutive daily water leaching events. For the control-release fertilizers, Nutricote, Meister and Osmocote, 70%–80% of the coated oxadiazon was released in the first 3 leaching events; each leaching event after the 7th leaching event contained less than 1% of total applied oxadiazon. In contrast, 56% of the total applied oxadiazon was leached from Polyon 24N–1.7P–10K (24–4–12) in the first 3 leachings and similar percentages of oxadiazon were leached over each of the last 11 leaching events. Coating the five fertilizers with isoxaben produced similar results. A second experiment evaluated the effects of the addition of Prime Oil, Complex (sticker), Plex (sticker), and Intac (sticker) on release rates of oxadiazon-coated Osmocote 17N–3.1P–10K (17–7–12). Oxadiazon-coated Osmocote alone and oxadiazon-coated Polyon alone were also evaluated. Eighty-five percent of the total applied oxadiazon was leached from oxadiazon-coated Osmocote alone during the first leaching event and less than 1% was recovered with each consecutive leaching after the third leaching. Oxadiazon-coated Osmocote treated with Plex responded similarly to oxadiazon-coated Osmocote. Oxadiazon-coated Osmocote treated with Complex, Intac, or Prime Oil and oxadiazon-coated Polyon lost 21%, 20%, 16%, and 24%, respectively, of the applied herbicide after the first leaching event. Thereafter, nearly equal amounts of oxadiazon (5%) were leached from Complex, Prime Oil, Intac and Polyon alone from the 6th through the 11th leaching events.

Index words: leaching, control-release fertilizer, water quality.

Herbicides used in this study: Ronstar (oxadiazon), 3-[2,4-dichloro-5-(methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3H)-one; (isoxaben), N-[3-(l-ethyl-l-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide.

Significance to the Nursery Industry

This study demonstrates that oxadiazon-coated Polyon 24N–1.7P–10K (24–4–12) releases less herbicide in the first few leaching events following application than several other commonly used control-released fertilizers. Polyon has greater surface area and also exhibits surface erosion from irrigation events. Addition of either Complex or Intac stickers or Prime Oil to oxadiazon-coated Osmocote created a more consistent rate of oxadiazon leaching. These data are useful in developing future alternative herbicide application techniques aimed at reducing non-target herbicide loss from container production areas while maintaining effective weed control.

Introduction

In nursery crop production, herbicides are typically broadcast over the top of the containers 3 or 4 times annually (3). Broadcast application results in up to 86% herbicide loss depending on plant growth, habit and container spacing (8). Recent reports have found elevated herbicide levels in nursery runoff water, suggesting that non-target herbicide losses may be a source of pesticide contamination of local drinking water supplies and surrounding bodies of water (2, 5, 7). Therefore alternatives to broadcast application are needed to reduce potential problems with herbicides in nursery runoff water.

Several approaches have been evaluated to reduce herbicide loss from container grown nursery crops, including containment ponds (2). Their study concluded that herbicides did not accumulate in either pond sediment or water due to herbicide degradation in the containment pond. Another approach to reducing nontarget herbicide loss is slow release tablets impregnated with herbicide, however, low water solubility resulted in insufficient weed control (6, 9, 10). This limitation can be partially overcome by adding a surfactant to the herbicide (4). More recently, several control-release fertilizers (CRFs) coated with oxadiazon were evaluated for weed control (1). This technique used about 80% less herbicide than traditional broadcast application. Weed control differed among the oxadiazon-coated CRFs, suggesting that characteristics of the fertilizer influence herbicide activity.

The objective of this research was to determine oxadiazon leaching rates from oxadiazon-coated fertilizers and to evaluate factors affecting leaching rates. Additionally, we sought to determine if applying either a sticker or an oil to oxadiazon-coated Osmocote would enhance uniformity of oxadiazon leaching.

Materials and Methods

Experiment 1. Five commonly used CRFs were evaluated: Meister 24N–1.7P–5.7K (24–4–7, Helena Chemical Co., Memphis, TN), Nursery Special 12N–2.6P–5K (12–6–6, Pursell Industries, Sylacauga, AL), Polyon 24N–1.7P–10K (24–4–12, Pursell Industries), Osmocote 17N–3.1P–10K (17–7–12, Scotts Co., Marysville, OH), and Nutricote 20N–3.1P–8K (20–7–10, Florikan E.S.A. Corp., Sarasoto, FL).

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Table 1. Number of leaching events required to remove 70% and 90% of total applied oxadiazon.

		Leachings required	
Fertilizer	Formulation	70%	90%
Osmocote	17–7–12	2.2c[z]	5.1d
Nutricote	20–7–10	1.9c	4.0d
Meister	24–4–7	3.8bc	7.5c
Nursery Special	12–6–6	5.8a	10.4ab
Polyon	24–4–12	6.3a	11.3a
Glass Beads	—	4.8ab	8.8bc

[z]Mean separation within columns by Duncan's multiple range test, P = 0.05.

Glass beads, 4 mm (0.16 in) in diameter were also coated with oxadiazon to serve as a nonabsorbent control. Fertilizers were coated with commercially-formulated oxadiazon (Ronstar 50WP) supplemented with sufficient ^{14}C-oxadiazon to facilitate detection. An aqueous solution of 5.0 mg ai/ml was prepared using both formulated and ^{14}C-oxadiazon. This solution (492 microliters) was applied to 20 g (0.044 lb) of each fertilizer, and allowed to air dry for 48 h. The resulting concentration of oxadiazon to fertilizer was 0.12 mg ai/g.

Twenty grams (0.044 lb) of each oxadiazon-coated fertilizer was placed into each separatory funnel and 20 ml (0.7 oz) of water added, slightly covering the fertilizer. After 30 minutes, water was allowed to drain into a 125 ml (4.2 oz) flask for 10 minutes. Leachate volume was measured and 1 ml (0.03 oz) subsamples were assayed for ^{14}C using liquid scintillation spectrometry (11). This procedure was repeated daily for 14 days. The amount of oxadiazon in each leaching was determined by multiplying the amount of radioactivity in the 1 ml (0.03 oz) subsample by the volume of leachate collected. Treatments were replicated 3 times in a completely randomized design, and the entire experiment was repeated twice. Data are pooled because results were similar. The number of leaching events required to remove 70 to 80% of the total applied oxadiazion was determined by Duncan's Multiple Range test (P = 0.05) (Table 1).

Similar procedures were used to evaluate isoxaben release from isoxaben-coated CRFs, except only 11 leaching events were sampled. Materials and methods were similar to the oxadiazon study, except the predetermined isoxaben rate was 1.1 kg ai/ha (1.0 lb ai/A). This study was conducted to determine if isoxaben release rates from the different fertilizers would be similar to those of oxadiazon.

Experiment 2. Osmocote 17N–3.1P–10K (17–7–12) was coated with oxadiazon as previously described. The oxadiazon-coated Osmocote was then coated with 200 microliters of either Complex (sticker; Riverside/Terra Corp.

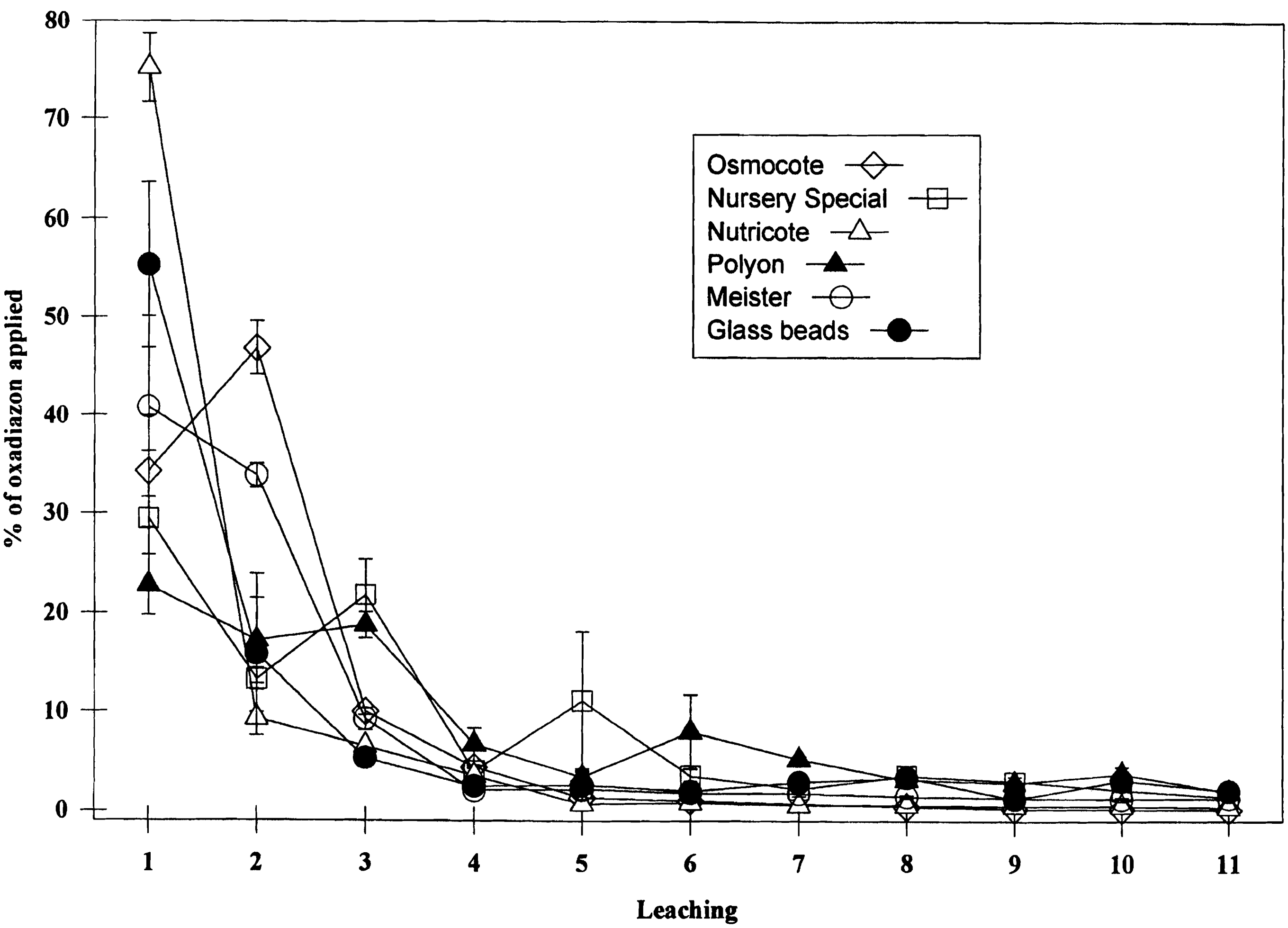

Fig. 1. ^{14}C-oxadiazon recovered from oxadiazon-coated fertilizers and glass beads over consecutive leachings.

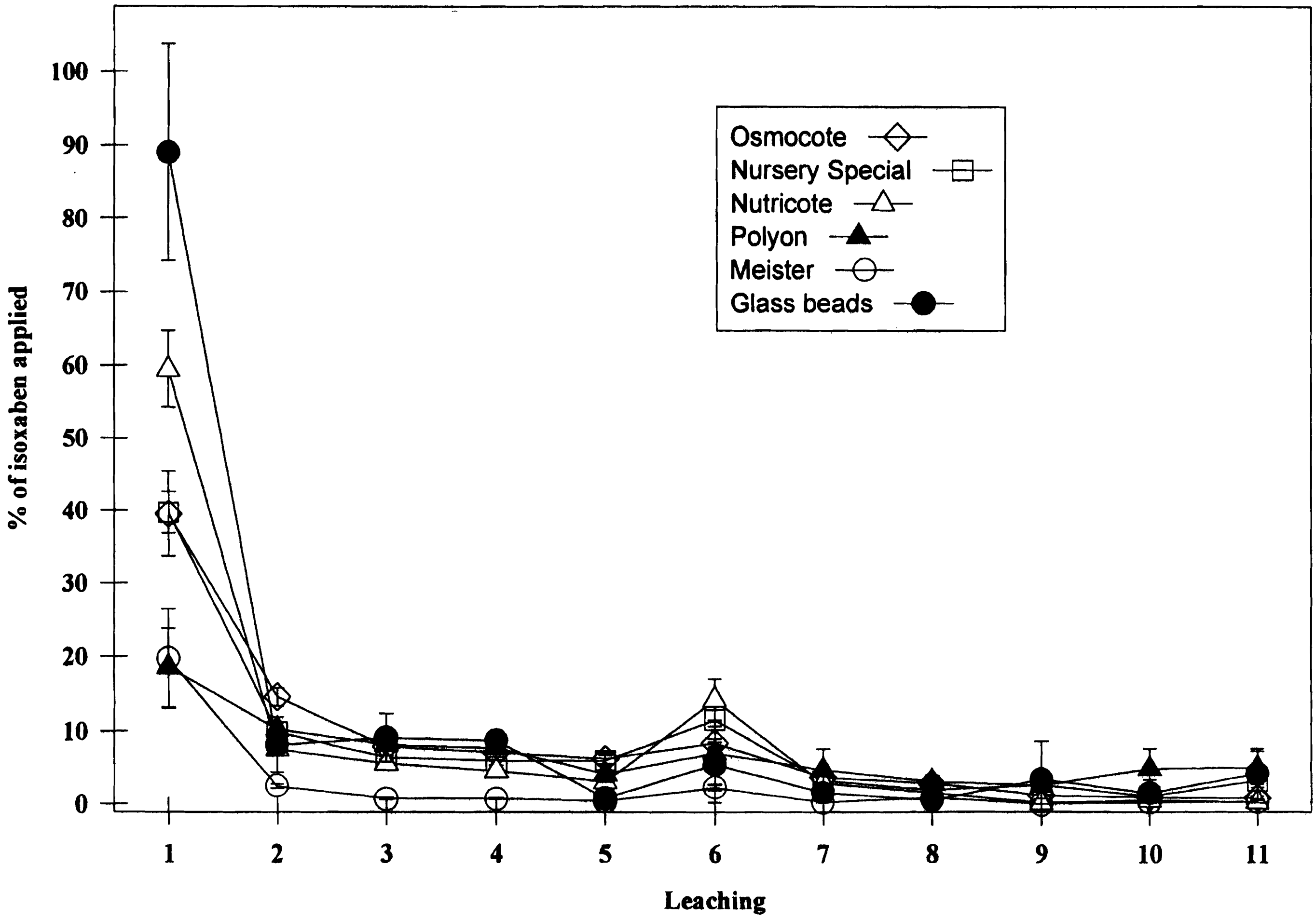

Fig. 2. ^{14}**C-isoxaben recovered from isoxaben-coated fertilizers and glass beads over 11 leachings.**

Sioux City, IA), Plex (sticker; Riverside/Terra Corp.), Prime Oil (Riverside/Terra Corp.), or Intac (Loveland Industries Inc., Greely, CO). Oxadiazon-coated Osmocote alone and oxadiazon-coated Polyon alone were also included as control treatments. The 14-day leaching and oxadiazon detection procedures were as previously described. Treatments were replicated 3 times in a completely random design.

Surface characteristics of fertilizers. Fertilizer surface area was determined by passing 50 g (0.11 lb) of each fertilizer through a nested series of 9 screens with a progression of precisely-sized openings from 0.31 to 11.1 mm (0.0012 to 0.043 in). The number of particles retained by each screen, as well as the surface area for a single sphere retained in each screen size (calculated from the given diameter of each screen) was determined. Summing number of particles retained by each screen size and multiplying that number by the surface area of a single sphere in that screen then summing across all screens provided the total surface area of the fertilizer sample.

Random samples of 3 leached prils (14 days) and 3 non-leached prils of Polyon and Osmocote were collected. Fertilizer prils were coated with 14K gold, and surface texture examined with a DMS 940 (Zeiss Co., Thornwood, NY) scanning electron microscope at 300× magnification to evaluate changes in surface texture after leaching.

Results and Discussion

Oxadiazon release rates, Experiment 1. After one leaching, ^{14}C-oxadiazon recovered from glass beads and Nutricote exceeded 50% of the total applied (Fig. 1). Meister and Osmocote released 44% and 35%, respectively. Nursery Special (30%) and Polyon (22%) released the lowest percentages with the first leaching. With the third leaching, 18% of total applied oxadiazon was recovered from oxadiazon-coated Polyon while less than 10% was recovered from the glass beads or the other fertilizers. After three leaching events, 70% to 80% of the total oxadiazon applied during the study was recovered from Meister, Osmocote and Nutricote fertilizers, while 56% was recovered from Polyon (Fig. 1). After the fifth leaching, oxadiazon-coated Polyon consistently leached the highest level of oxadiazon. For example, total oxadiazon recovered at the 7th leaching event was less than 2.0% from Meister, Nutricote or Osmocote compared to 5.1% for Polyon. Polyon required about 3 times the number of leaching events to remove 70% of the applied oxadiazon compared to Nutricote and Osmocote fertilizer (Table 1). The number of leaching events required to remove 70% of the oxadiazon from Nursery Special was similar to Polyon. This would be expected since Nursery Special contains Polyon prils. Polyon and Nursery Special also required the most leaching events to remove 90% of the applied oxadiazon (Table 1). In previous work (1), oxadiazon-coated Polyon and Nursery Special

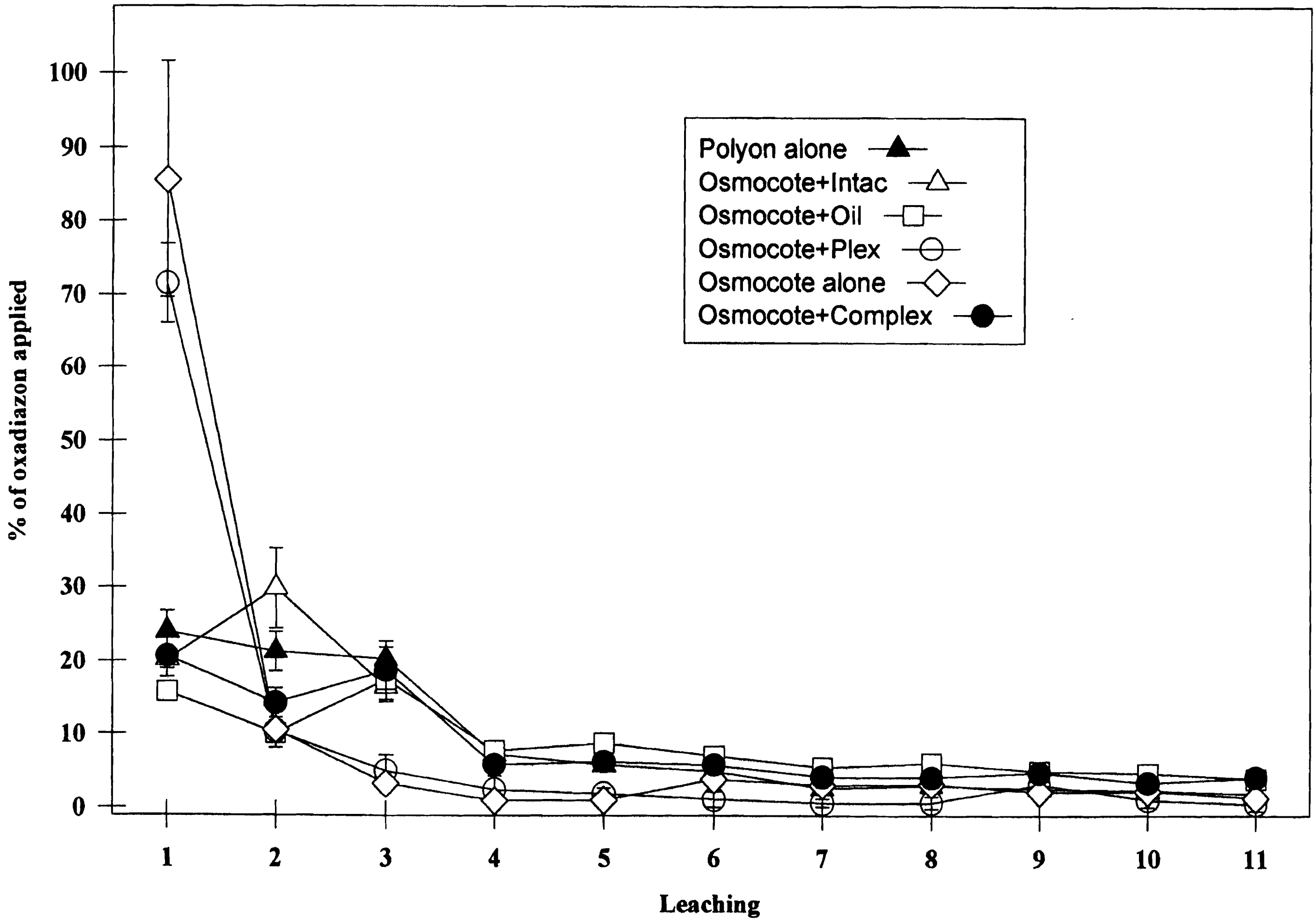

Fig. 3. **^{14}C-oxadiazon recovered from oxadiazon-coated fertilizers and additives over consecutive leachings.**

fertilizers were more effective in controlling weeds than Osmocote. This enhanced weed control obtained in the field likely resulted from the extended release of herbicide from Polyon. Results with isoxaben were similar to those of oxadiazon (Fig. 2). Isoxaben recovery from Polyon on the last leaching events (days 7, 8, 10, 11) was numerically greater than any other fertilizer.

Oxadiazon leaching rates, Experiment 2. The control treatments of oxadiazon-coated Osmocote and Polyon alone resulted in leaching patterns similar to those in the first experiment (Fig. 3). In the first leaching, 85% of the applied oxadiazon was recovered from Osmocote, while only 24% was leached from Polyon. After the third leaching, Osmocote was essentially depleted as evident by less than 1% recovery from the remaining 11 leaching events. Oxadiazon recovery from Polyon ranged from 20–25% during each of the first 3 leaching events and was consistently higher than Osmocote throughout the duration of the study except on day 1. When Plex was added to the oxadiazon-coated Osmocote fertilizer, oxadiazon recovery was similar to that of oxadiazon-coated Osmocote alone (Fig. 3). However, Prime Oil plus oxadiazon-coated Osmocote fertilizer reduced oxadiazon recovery compared to oxadiazon-coated Osmocote alone. With the first leaching, 16% of the applied oxadiazon was recovered from the Prime Oil plus oxadiazon-coated Osmocote followed by recovery rates between 7% and 10% through the 6th leaching. About 5% was recovered in the 7th through 11th leaching events. When Intac or Complex was coated onto oxadiazon-coated Osmocote, oxadiazon recovery was similar to the pattern obtained with the addition of Prime Oil.

Surface characteristics of fertilizers. Polyon surface area was 23% greater than the fertilizer with the next largest surface area. Fertilizer surface areas expressed as cm^2/50 g (in^2/0.11 lb) were: Polyon, 813 (126); Meister, 633 (98); Osmocote, 626 (97); Nursery Special, 547 (84); and Nutricote, 465 (72). Glass beads had the lowest surface area with 228 cm^2 (35 in^2). Average pril diameter was as follows: Nutricote 0.4107 cm (0.1617 in); glass beads 0.3599 cm (0.1417 in); Meister 0.2647 cm (0.1047 in); Osmocote 0.2583 cm (0.1017 in); Nursery Special 0.2219 cm (0.0874 in); and Polyon 0.2184 cm (0.0860 in). The greater surface area of Polyon may contribute to its slow release and weed control properties (1). When these smaller prils are spread evenly over the container medium surface, a more even herbicide distribution is obtained relative to a fertilizer with larger prils. This conclusion is supported by previous work with herbicide tablets that showed definite circular rings of weed control around the tablets (4). Finally, assuming equal volumes of water from daily irrigation, greater fertilizer surface area may be more effective in retaining the herbicide against possible displacement, assuming adsorption is related to physical characteristics.

The surface of Polyon underwent apparent surface erosion over the 14 leaching events. Initial roughness of Polyon changed to a smoother more uniform appearance after leaching (data not shown). This suggests the loss of the fertilizer coating that would result in herbicide release as well. The surface structure of the other fertilizers appeared similar before and after the 14 leachings.

Superior weed control obtained with oxadiazon-coated Polyon in previous work (1) may be attributed to its ability to release the herbicide over a longer period of time compared to the other control-release fertilizers tested. This improved weed control may result from either more uniform distribution over the container medium surface area or erosion of Polyon's surface. The addition of Intac, Prime Oil, or Complex to oxadiazon-coated Osmocote altered the oxadiazon recovery rate to a rate similar to that obtained with oxadiazon-coated Polyon. Thus, superior weed control obtained with oxadiazon-coated Polyon in previous work (1) should be available with oxadiazon-coated Osmocote with the addition of one of these additives. These data may provide future options to the nursery industry in reducing nontarget herbicide loss while maintaining effective weed control.

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