Mulch Depth Affects Weed Germination[1]

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Abstract

With environmental concerns increasing, non-chemical weed control in container plant production is increasing in the United States. Pine bark mini-nuggets were evaluated as a non-chemical weed control technique for two weed species; *Chamaesyce maculata* (L.) Small (spotted spurge) and *Eclipta alba* (L.) Hassk.(eclipta). On June 19, 2006, seed (25 per container) were directly placed on the potting substrate surface of #3 containers before mulching with pine bark mini-nuggets to a depth of either 0, 1.27 or 2.54 cm (0, 0.5 or 1.0 in). Additional treatments consisted of applying the mini-nugget mulch at either 1.27 or 2.54 cm (0.5 or 1.0 in) on the potting substrate then overseeding with either spotted spurge or eclipta. Eclipta number per container were 87% less 60 days after seeding (DAS) with the 1.0 in mulch depth compared to non-mulched. Furthermore, spotted spurge fresh weight (FW) was reduced by 45 and 87% (0.5 and 1.0 in, respectively) compared to the non-mulched treatment. The experiment was repeated on August 30 and spurge number per container was 90% less 60 DAS in the 1.0 inch mulch treatment compared to the non-treated containers. A third and fourth experiment also demonstrated that pine bark mini-nuggets have potential to provide non-chemical weed control in nursery crops grown in #3 containers. Results, suggest that with proper application pine bark mini-nuggets can enhance weed control in container nurseries.

Index words: pine bark mini-nuggets, container production, non-chemical control.

Significance to the Nursery Industry

For many years pine bark mini-nuggets have provided successful weed control in the landscape. Pine bark is readily available, economical, and aesthetically acceptable to consumers. Our results showed that pine bark mini-nuggets as a mulch can enhance weed control in container-grown nursery crops. Therefore, potential to reduce herbicide use in nursery production with mini-nugget mulch exists. Current practice for nursery growers is to reapply herbicides as often as every six weeks or after scouting for weeds; often making five or more applications annually. Herbicide applications could potentially be reduced by utilizing pine bark mini-nuggets.

Introduction

Traditionally, weed control during nursery production has been managed through hand weeding and/or herbicides. However increased labor cost has made hand-weeding cost prohibitive as the sole method of weed control (11, 14). With these increased labor costs, herbicides have become widely accepted as a means for weed control (10). However, environmental concerns over chemical weed control have encouraged the nursery industry to evaluate alternative weed control options (19). Preventing weed growth with the use of non-chemical control methods has been steadily on the increase since the early 1990s in European countries (20). In the United States, non-chemical control methods were re-addressed in 1984 after herbicide resistance became an issue (2). Ryan (27) first reported herbicide resistance in common groundsel (*Senecio vulgaris*) to atrazine and simazine. Warwick (29) stressed the importance of non-chemical weed control after discovering more than 100 herbicide resistant species. Rao (24) reported an increase of herbicide resistance in a 10-year span equal to that reported by Holt and LeBaron (13) of insecticide resistant biotypes over a 50-year span. Relying merely on herbicides for weed control can lead to herbicide resistant weeds (17). Recommendations have been made to rotate herbicides with different modes of action (MOAs) (12, 17). By using several MOAs, herbicide-resistant weeds are less likely to develop. Furthermore, if not controlled, herbicide resistance can lead to an increase in herbicide use as a result of inadequate weed control with current herbicides (17).

Non-chemical weed control programs can help reduce herbicide reliance (16). Common practice in many nurseries such as those in Oregon is to use mulches as a form of weed control for herbicide sensitive crops or in enclosed areas (1). In theory applying mulch over a soil surface or substrate prevents light passage (15), which can prevent the seed of some weed species from germinating (4). One key to having a successful weed control program is to prevent habitats that are conducive for weed germination and growth. This is particularly important in container-grown crops where water and light conditions are favorable for weed growth. Once weeds infest container-grown crops they become competitors with the marketable crop for water, light and nutrients (3) and can reduce the growth of container-grown nursery crops (7, 14). Furthermore, container plants infested with weeds are less marketable than weed-free containers (21). Billeaud and Zajicek (5) used pine bark nuggets for weed control in a field study and reported fewer weeds compared to the control (no mulch). Additionally, the suppression of weed growth reduced moisture loss through transpiration and allowed the soil surface layer to stay moist longer (26). Lohr and Pearson-Mims (18) showed pine bark mulch reduced water use during the early stages of growth of 'Impulse Rose' impatiens when grown in 19.0 cm (7.5 in) azalea pots. Duryea et al. (9) analyzed the chemical make up of several mulches including pine bark and concluded that pine bark, based on subsidence, decomposition, allelopathy, soil pH and color change, ranked in the top three landscape mulches. Ad-

[1]Recieved for publication June 26, 2008; in revised form November 18, 2008.

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ditionally, large particle size and hydrophobic properties of fresh pine bark are not conducive for weed germination (25). Richardson et al. (25) reported reduced oxalis and bittercress numbers in large containers (#7) when pine bark mini-nuggets were applied to a depth of either 3.8 or 7.62 cm (1.5 or 3 in). In terms of numbers, the vast majority of container grown nursery crops in the south are produced in #1 and #3 gallon containers which have a limited volume. Therefore, our objective was to evaluate pine bark mini-nugget mulch as a form of weed control in #3 gallon containers.

Materials and Methods

Experiment 1. On June 19, 2006, at the Paterson Greenhouse Complex, Auburn University, Auburn, AL (zone 8), #3 containers were filled with pine bark:sand (6:1, by vol), amended with 6.35 $kg \cdot m^{-3}$ (14 $lbs \cdot yd^{-3}$) of 17–6–12 (17N–2.6P–10K) Polyon (control-release fertilizer), 2.27 $kg \cdot m^{-3}$ (5.0 $lbs \cdot yd^{-3}$) of dolomitic lime, and 0.89 $kg \cdot m^{-3}$ (1.5 $lbs \cdot yd^{-3}$) of Micromax, and irrigated with overhead impact sprinklers. Pine bark mini-nuggets were obtained from a local supplier for \$16/yd³. Pine bark mini-nuggets had a particle size distribution of: 11% between 2.54 and 5.08 cm (1–2 in), 68% between 1.27 and 2.54 cm (½–1 in), 14 % between 0.64 and 1.27 cm (¼–½ in), and 7% was less than 0.64 cm (¼ in). Two weed species, spotted spurge (*Chamaesyce maculata*) and eclipta (*Eclipta alba*), were evaluated in a separate set of containers. Each container was overseeded with 25 seed of the respective weed. Weed seed had been collected the previous summer and stored overwinter at 1.1C (34F). An augmented factorial treatment arrangement was used. The first four treatments consisted of two mulch depths, 1.27 and 2.54 cm (0.5 and 1.0 in), and two weed seed placements (above and below mulch). The fifth and final treatment was seeded but not mulched. The experiment was conducted as a completely random design. After treatment application, containers were placed in full sun under overhead irrigation and irrigated again. Weed number was recorded at 15, 30, and 60 days after seeding (DAS) and weed fresh weight was collected 60 DAS.

Preliminary data analysis which addressed the factorial arrangement and excluded the non-mulched fifth treatment, revealed that weed growth was significantly influenced by the main effect of both mulch depths and weed seed placement ($P \leq 0.05$). Consequently, individual treatment means are presented and Duncan's Multiple range test ($P = 0.05$) was used to separate individual treatment means (28).

Experiment 2. This experiment was a repeat of Experiment 1. On August 30, 2006, containers were filled and overseeded with spurge or eclipta at 25 seed per container. Weed number was recorded at 15, 30, and 60 DAS and weed fresh weight was collected 60 DAS.

Experiment 3. Work was initiated on April 25, 2006, at Tom Dodd's Nursery in Mobile, AL. Three weed control techniques were evaluated on newly potted #5 *Pinus taeda* (loblolly pine) containers in a commercial nursery; pine bark mini-nugget mulch was applied to a depth of 3.81 or 7.62 cm (1.5 or 3.0 in), or Showcase (5 $lbs \cdot aia^{-1}$) (200 lbs $product \cdot A^{-1}$) herbicide applied at initiation of study, no weed seed were sown. Containers were placed in the field in full sun under overhead impact irrigation. Data collected included percent coverage at 30 and 60 days after treatment (DAT), weed number at 30, 60, and 150 DAT and initial and final height and caliper measurements [1.27 cm (1.0 in) above media].

Experiment 4. This study was initiated at the Ornamental Horticulture Research Station in Mobile, AL on April 21, 2006, when #1 liners (*Ilex* sp. and *Buddleia davidii* 'Lochnich') were potted into #3 squat containers using a 3:1 pine bark:peat moss substrate amended with 6.1 $kg \cdot m^{-3}$ (13.5 $lbs \cdot yd^{-3}$) 15–9–12 (15N–3.9P–10K) Osmocote Plus, 2.7 $kg \cdot m^{-3}$ (6 $lbs \cdot yd^{-3}$) dolomitic limestone, and 0.9 $kg \cdot m^{-3}$ (2 $lbs \cdot yd^{-3}$) gypsum. The same three weed control techniques described in Experiment 3 were initiated on April 25, 2006. Containers were placed in the field under overhead impact irrigation, no weed seed were sown. Data collected included initial growth indices (height + width + perpendicular width ÷ 3) and growth indices 170 DAT, weed number at 30 and 60 DAT, and percent container surface weed coverage at 30, 60, and 170 DAT.

Results and Discussion

Experiment 1 — Eclipta. Eclipta number per container was less in mulched containers compared to non-mulched containers (Table 1). This is a typical response when using mulch as a form of weed control (6, 23). Eclipta number per container were similar regardless of whether seed was placed below or above the mulch. Our data was similar to previous research, indicating that an increase in thickness of mulch improves weed control (5, 22, 27). Fifteen and 30 DAS, weed number was reduced by 67 and 57% in the 1.27 cm (0.5 in), and 99 and 93 % in the 2.54 cm (1.0 in) mulch, respectively, compared to the non-mulched treatment. Sixty DAS, weed number was reduced by 54 and 87% in the 1.27 and 2.54 cm (0.5 and 1.0 in) mulch, respectively, compared to the non-mulched treatment. Eclipta fresh weight (FW) was significantly less in both mulching depths; 49 and 89% in 1.27 and 2.54 cm (0.5 and 1.0 in), respectively, compared to the non-mulched treatment. Mulching to a depth of 2.54 cm (1.0 in) resulted in better weed control compared to mulch applied at 1.27 cm (0.5 in) on all dates. Additionally, there was an interaction between placement of seed and mulch depth in FW of eclipta (Table 2). Eclipta seed placed below 2.54 cm (1.0 in) of mulch had less FW compared to all other treatments.

Experiment 1 — Spurge. Regardless of seed placement, spurge number was less in both treatments compared to the non-mulched control (Table 1). Spurge numbers per container were greater for seed placed below the mulch at 30 and 60 DAS compared to seed placed above the mulch. While spurge FW was not significant with seed placement ($P = 0.05$), FW tended to be greater when seed were placed below the mulch. Applying 2.54 cm (1.0 in) mulch resulted in reduced weeds compared to applying 1.27 cm (0.5 in). Fifteen DAS spurge number was reduced by 61 and 99% in the 1.27 and 2.54 cm (0.5 and 1.0 in) mulch, respectively, compared to the non-mulched treatment. Thirty and 60 DAS spurge number was reduced by 55 and 45% in the 1.27 cm (0.5 in) and 92 and 74% in the 2.54 cm (1.0 in) mulch, respectively, compared to the non-mulched treatment.

At both 15 and 30 DAS an interaction was detected between mulch depth and seed placement (Table 2). There was no difference in spurge number when mulch depth was 2.54 cm (1.0 in), regardless of seed placement. However, at the

Table 1. **Main effect means of pine bark mini-nugget mulch to control eclipta and spurge, Experiment 1.**

	Eclipta				Spurge			
	Weed number			FW[z]	Weed number			FW
Experimental variable	**15 DAS[y]**	**30 DAS**	**60 DAS**	**60 DAS**	**15 DAS**	**30 DAS**	**60 DAS**	**60 DAS**
Placement of seed[x]								
Below mulch	1.6	1.8	1.6	304.0	2.4	2.8	3.6	269.2
Above mulch	1.4	2.6	2.1	343.6	0.6	1.3	2.3	166.7
Mulching depth								
0.5 inch	2.9	3.7	2.9	529.6	2.9	3.5	4.1	354.0
1.0 inch	0.1	0.6	0.8	118.1	0.1	0.6	1.9	81.9
Non-mulched[w]	8.9	8.1	6.3	1040.4	7.5	7.8	7.4	644.5
ANOVA main effects:				probability				
Placement	0.641	0.172	0.383	0.543	0.001	0.005	0.125	0.063
Mulch depth	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.013	<0.001
Interaction	0.485	0.458	0.110	0.005	0.002	0.035	0.070	0.002

[z]Fresh weight (grams).
[y]Days after seeding.
[x]Eclipta or spurge overseeded @ 25 seed per container below or above mulch.
[w]Weeds were seeded directly onto the potting substrate, no mulch applied.

1.27 cm (0.5 in) mulch depth, spurge numbers were greater when seed were sown below the mulch. Similarly, spurge fresh weights were more than doubled when spurge seed were sown below (494.9 gm) the 1.27 cm (0.5 in) mulch compared to fresh weights of seed sown above (213.2 gm) the 1.27 cm (0.5 in) of mulch. Although not statistically significant, spurge fresh weights tended to be greater at the 2.54 cm (1.0 in) mulch depth (120.2 gm) when seed were sown above the mulch compared to seed sown below the mulch (43.6 gm). Our results concur with previous work that demonstrated that spurge seed buried deeper than 1.27 cm (0.5 in) do not germinate well (8).

Experiment 2 — Eclipta. Similar to the first experiment, eclipta numbers were similar regardless of seed placement (Table 3). For example, eclipta number was reduced by 56, 37, and 56% (below mulch) and 65, 41, and 62% (above mulch) at 15, 30, and 60 DAS, compared to the non-mulched, respectively. Applying mulch to a depth of 2.54 cm (1.0 in) resulted in 85% less eclipta per container compared to the non-mulched containers and 76% less than the 1.27 cm (0.5 in) application, 15 DAS. Whereas the 1.27 cm (0.5 in) application reduced eclipta number by 36% compared to the non-mulched treatment. Similar trends followed at 30 and 60 DAS; 63 and 79% reduction compared to the non-mulched and 56 and 64% reduction compared to the 1.27 cm (0.5 in), respectively. Eclipta FW was similar with below and above mulch seed placement. However, mulch applied to a depth of 2.54 cm (1.0 in) resulted in significantly less FW (35.1 g) compared to both the non-mulched (339.4 g) and the 1.27 cm (0.5 in) (176.5 g) mulch application. There was no interaction effect between placement of seed and mulch depth.

Experiment 2 — Spurge. Similar to Exp. 1, spurge numbers tended to be greater when seed were placed below the mulch; however it was significant only at 30 DAS (Table 3). Spurge number was less, regardless of placement of seed, compared to the non-mulched. When seed was placed below

Table 2. **Preformance of selected individual treatments using pine bark mini-nuggets, Experiment 1.**

Treatment		Eclipta				Spurge			
		Weed number			FW[z]	Weed number			FW
Placement[y]	**Depth**	**15 DAS[x]**	**30 DAS**	**60 DAS**	**60 DAS**	**15 DAS**	**30 DAS**	**60 DAS**	**60 DAS**
Below	0.5	—	—	—	606.6b[w]	4.6b	4.8b	—	494.9a
Below	1	—	—	—	1.4d	0.1c	0.8d	—	43.6c
Above	0.5	—	—	—	452.5b	1.3c	2.3c	—	213.2b
Above	1	—	—	—	234.7c	0.0c	0.4d	—	120.2bc
Non-mulched[v]	0	—	—	—	1040.4a	7.5a	7.8a	—	644.5a

[z]Fresh weight (grams).
[y]Eclipta or spurge overseeded @ 25 seed per container below or above mulch.
[x]Days after seeding.
[w]Means within a column with different letters are significantly different, according to Duncan's Multiple Range test (α=0.05).
[v]Weeds were seeded directly onto the potting substrate, no mulch applied.

Table 3. Main effect means of pinebark mini-nuggets to control eclipta and spurge, Experiment 2.

	Eclipta				Spurge				
	Weed number			FW[z]	Weed number				FW
Experimental variables	15 DAS[y]	30 DAS	60 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS	60 DAS
Placement of seed[x]									
Below	8.7	5.9	6.2	117.03	3.6	7.6	5	3.3	8.4
Above	7	5.6	5.3	94.6	1	2.1	3.4	2.2	3.1
Mulching depth									
1/2 inch	12.7	7.9	8.4	176.5	4.1	8.3	7.3	4.3	9.2
1 inch	3	3.5	3	35.1	0.4	1.4	1.2	1.2	2.3
Non-treated[w]	19.8	9.5	14.1	339.4	22.6	13.1	20.1	12.5	103.3
ANOVA main effects:					probability				
Seed placement	0.538	0.791	0.389	0.452	0.216	0.026	0.268	0.176	0.245
Mulch depth	0.001	0.001	<0.0001	<0.0001	0.079	0.006	0.000	0.000	0.136
Interaction	0.665	0.318	0.773	0.499	0.413	0.098	0.964	0.687	0.864

[z]Fresh weight (grams).

[y]Days after seeding.

[x]Eclipta or spurge overseeded @ 25 seed per container either below or above mulch.

[w]Weeds were seeded directly onto the potting substrate, no mulch applied.

mulch, spurge number per container was reduced by 84% compared to the non-mulched, and 96% less when spurge seed was placed above mulch, 15 DAS. Applying 2.54 cm (1.0 in) mulch resulted in fewer spurge numbers per container at 30 and 60 DAS compared to the 1.27 cm (0.5 in) mulch by 83 and 72%. However, both mulch depths resulted in less weed number compared to the non-mulched; 82, 37, and 68% [1.27 cm (0.5 in)] and 98, 89, and 90% [2.54 cm (1.0 in)] at 15, 30, and 60 DAS, respectively. Applying mulch, regardless of seed placement or mulch depth, reduced spurge FW compared to non-mulched containers by more than 90%.

Experiment 3. No weeds were observed at 30 or 60 DAT in pine bark mulch or Showcase treatments, with the exception of 60 DAT Showcase treatment (13.3) (Table 4). Weeds in the Showcase treatment were primarily small bittercress that had just begun to germinate. Percent coverage of the containers revealed that only about 5% of the container surface was covered with weeds in the Showcase treatment versus 42% in the non-treated control. At 150 DAT, weed numbers in mulch treatments were less than Showcase and non-treated treatments. End of the season (150 DAT) there were 70 and 82% [3.81 and 7.62 cm (1.5 and 3.0 in), respectively] less weeds in the pine bark mulch compared to the non-treated control. Showcase treated containers had similar weed numbers to mulched containers at 30 and 60 DAT compared to the non-treated containers. However at 150 DAT mulched containers had less weed numbers than Showcase and the non-treated containers. Regardless of weed control technique, loblolly pine height and caliper were similar compared to the non-treated.

Experiment 4. Statistically there were less weeds and lower percent weed coverage in all three weed control techniques at 30 and 60 DAT, regardless of plant species, compared to the non-treated (Table 5). At the end of the season, hollies had 26% less weed coverage in the pine bark mulch [3.81 cm (1.5 in)], 77% less coverage in the pine bark mulch [7.62 cm (3.0 in)], and only 7% less weed coverage in the Showcase treatment, compared to the non-treated control. Buddleia had

Table 4. Influence of mulch and Showcase on weed control in container-grown *Pinus taeda* loblolly pine, Experiment 3.

		Weed number[z]			Percent coverage[y]		Height[x]		Caliper[w]	
Treatment	Rate	30 DAT[v]	60 DAT	150 DAT	30 DAT	60 DAT	15 DAT	150 DAT	15 DAT	150 DAT
Pine bark mulch	1.5"	0.0b[u]	0.0b	2.9b	0.0b	0.0b	42.0a	154.3a	7.0a	25.2a
Pine bark mulch	3.0"	0.0b	0.0b	1.7b	0.0b	0.0b	43.7a	153.2a	7.3a	23.2a
Showcase[s]	200 lb/A	0.0b	13.3b	8.7a	0.0b	5.5b	45.1a	137.6a	7.7a	23.2a
Non-treated	—	7.0a	36.4a	9.6a	2.6a	42.5a	43.6a	148.8a	8.0a	25.0a

[z]Weed number per container (mainly bittercress).

[y]Percent weed coverage per container (0–100%).

[x]Height (cm).

[w]Caliper (mm).

[v]DAT = days after treatment.

[u]Means within a column with different letters are significantly different, according to Duncan's Multiple Range test (α = 0.05).

[t]Research was conducted at Tom Dodd Nurseries, Semmes, AL.

[s]Showcase = 5.0 lbs aia (isoxaben 0.25%, trifluralin 2.0%, oxyfluorfen 0.25%)

Table 5. Influence of mulch and Showcase on weed control in container-grown nursery crops, Experiment 4.

Treatment	Rate	Weed number[z] 30 DAT[w]	Weed number[z] 60 DAT	Percent coverage[y] 30 DAT	Percent coverage[y] 60 DAT	Percent coverage[y] 170 DAT	GI[x] 10 DAT	GI[x] 170 DAT
					Holly			
Pine bark mulch	1.5"	0.5b[v]	2.7c	0.8b	10.5b	72.5b	34.6a	67.6ab
Pine bark mulch	3.0"	0.0b	0.5c	0.0b	5.2b	22.5c	30.6a	75.9a
Showcase	200 lb/A	0.1b	21.1b	0.1b	25.0b	91.7ab	33.8a	66.4ab
Non-treated	—	17.0a	44.0a	38.5a	78.3a	98.3a	33.7a	59.4b
					Buddleia			
Pine bark mulch	1.5"	0.0b	1.8b	0.0b	2.0b	2.0b	39.1a	82.9a
Pine bark mulch	3.0"	0.0b	0.0b	0.0b	0.0b	0.0b	41.9a	75.1a
Showcase	200 lb/A	0.2b	0.7b	0.2b	3.5b	3.5b	41.9a	80.9a
Non-treated	—	23.3a	29.3a	13.5a	41.7a	41.7a	42.5a	76.5a

[z]Weed number per container: holly (pigweed, phyllanthus, oxalis, spurge, bittercress) buddleia (oxalis).

[y]Percent weed coverage per container (0–100%).

[x]Growth indices (height + width + perpendicular width / 3).

[w]Days after treatment.

[v]Means within a column with different letters are significantly different, according to Duncan's Multiple Range test ($\alpha = 0.05$).

[u]Research was conducted at Mobile Ornamental Research Station, Mobile, AL.

less weed coverage in all treatments (170 DAT) compared to the non-treated; 95% in the pine bark mulch [3.81 cm (1.5 in)], 100% in the pine bark mulch [7.62 cm (3.0 in)], and 92% less weed coverage in the Showcase treatment. Mulched or Showcase-treated buddleia or holly had equal to or better growth indices than non-treated plants at the end of the study. This data supports that reduced weed growth improves the crop growth by alleviating competition between weeds and the marketable crop (3).

Results indicate pine bark mini-nuggets applied to a depth of 1.27 cm (0.5 in) or greater can significantly reduce eclipta and spurge numbers in a #3 gallon container-grown crop with the 2.54 cm (1.0 in) depth providing the best control. Our results were similar to Broschat (6) who reported that weed seedlings can be suppressed by mulches. In Experiments 1 and 2 spurge number was greatly reduced compared to non-mulched containers. Increased spurge numbers when spurge seed were placed below 1.27 cm (0.5 in) mulch suggest that mulch applied at potting may be more effective than when applied during the growing season to recently hand weeded containers unless mulch is applied to a depth of 2.54 cm (1.0 in). With eclipta, seed placement had no effect on weed numbers throughout the test. When comparing mulched containers to containers treated with Showcase, mulched containers had similar or better weed control. Experiments 3 and 4 demonstrate the weed control potential of mulching in situations typically found in commercial nurseries when producing in #3 containers. While weed control was not 100%, weed numbers were about 80% less in the 7.62 cm (3.0 in) treatments compared to non-treated containers and crop growth was not affected by these mulch depths. These data are comparable to that of Richardson et al. (25) who reported that season long oxalis and bittercress control were obtained with 7.62 cm (3.0 in) of pine bark mulch without affecting growth of three different nursery crops. Control in our test was not 100%, however, spurge and eclipta are difficult summer weeds to control in the South. As we look to the future these data show that mulching #3 containers can reduce weed numbers without impacting plant growth and may have a place in future production practices, especially in nurseries that are in environmentally sensitive locations or for growers that may want to grow organically.

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