Effect of Coffee Grounds on Seed Germination©

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Aqueous coffee extracts (ACE) and spent coffee grounds (SCG) were evaluated for effects on seed germination of *Trifolium repens* (white clover), *Lolium perenne* (perennial rye), and *Amaranthus palmeri* (palmer amaranth). In Experiment 1, five different percentage ACE treatments (0%, 25%, 50%, 75%, and 100%) were mixed and added to petri dishes. Each petri dish had 25 seed of each weed species. White clover started germinating 1 day after seeding (DAS) in all treatments. By 8 DAS, nearly all white clover seed had germinated. However, visually the seedling size decreased as percentage ACE increased, suggesting that ACE might contain properties that deter seed from germinating. Furthermore, perennial rye seed had a lower germination rate, regardless of percentage ACE compared to the 0% ACE treatment. In Experiment 2, SCG and pine bark (PB) were evaluated as container mulch at five different depths (0, 0.5, 1.0, 1.5, and 3.0 inches). Results indicated that SCG as container mulch, have similar weed control to PB mulch by 14 DAS, at respected depths. Additionally, use of either SCG or PB at 0.5 and 1.0 inches depth, had less weeds compared to the nonmulched containers at 14 DAS.

INTRODUCTION

In 2005, individuals consumed 24.2 gal of coffee per year in the United States of America alone (Buzby and Haley, 2007). While this per capita is based on liquid consumption it does not account for the solid waste or coffee residue leftover after the brewing process. It is estimated that the daily volume of coffee residue is 0.91 kg for each kilogram of soluble coffee (Yen et al., 2005). In 2006/2007 world coffee production was estimated at 134.3 million bags, over 8 billion kg (USDA, 2007). Spent coffee grounds (SCG), which are the coffee residue after brewing, are considered municipal solid waste and normally end up in landfills. Once in a landfill, they take up space until they are degraded and due to the high presence of organic material, there needs to be adequate oxygen in order to be degraded or they can ferment and spontaneously combust (Silva et al., 1998). The amount of SCG is surprisingly overwhelming, for example, extension agents in Lane County, Oregon, collected 53 tons of coffee grounds from 13 local coffee shops in 2007 estimating that in 1 year Lane County produced around 500 tons of coffee grounds (62.5 large dump trucks) (Woods, 2008).

Previous research has suggested that SCG can be used as alternative fuels (Silva et al., 1998), soil additives (Yen et al., 2005), metal adsorbents (Utomo and Hunter, 2006), vermicompost (Orozco et al., 1996), landscape compost (Morikawa and Saigusa, 2008), mulch (Eshetu et al., 2007), and weed control (Sciarrappa et al., 2008). Morikawa and Saigusa (2008) composted ferrous sulfate with SCG for 60 days in plastic bags. Their findings showed that this compost combination decreased pH in alkaline soils, increasing plant available Fe. Additionally, mulching with coffee husk has shown to conserve soil moisture enough to significantly promote vegetative growth in pineapples when moisture is a limiting factor (Eshetu et al., 2007). Subsequently, coffee husk mulch had 85.5% weed control compared to their non-weeded/non-mulched control. Studies conducted by Sciarrappa et al. (2008) showed that mulching with coffee grinds to a depth of 1.6–3.1 in. provided 95% weed control in organic blueberry production.

Since SCG are a low cost by-product and there is more than 80 million tons produced a year, SCG could be an option for the green industry. Our objective for this study was to evaluate aqueous coffee extracts (ACE) on germination of three commonly found weed seeds and evaluate SCG as potential mulch for containers.

MATERIALS AND METHODS

For this study the local Starbucks® coffee shops in Starkville, Mississippi, provided SCG.

Experiment 1: Effect of ACE on Seed Germination. Treatments included four concentrations of ACE and reverse osmosis water (RO) was used as control. Stock ACE was developed by mixing 231 g of spent coffee grounds with 600 mL of water and stirring for 48 h on a stirrer plate (Corning Stirrer/Hotplate). The coffee solution (pH 5.39, EC 1.69 $dS{\cdot}m^{-1}$) was then filtered through cheese cloth. The ACE of various concentrations were formulated in 100 mL beakers as following: 25% ACE consisted of 10 mL of the stock ACE and 30 mL of RO, 50% consisted of 20 mL of stock ACE and 20 mL of RO, 75% consisted of 30 mL of stock ACE and 10 mL of RO, and 100% was 40 mL of stock ACE. Captain fungicide was added to each treatment based on recommended label rate of 1½ tbs/gal (0.088 g per 40 mL). Whatman® #1 filter paper was placed on the petri dishes. An aliquot of 4 mL of solution, was added to each petri dish to saturate the filter paper and 25 seeds of *Amaranthus palmeri* (palmer amaranth), *Lolium perenne* (perennial rye), and *Trifolium repens* (white clover) were placed in one petri dish (three species, 25 seeds per plate). There were five Petri dishes for each of the four ACE treatments and the control, and there were a total number of 25 Petri dishes in the experiment. All Petri dishes were placed in a growth chamber with 20 °C/15 °C (day/night temperatures) and 16-h photoperiod. Petri dishes were monitored daily, adding an additional milliliters of corresponding ACE solution to each plate as needed to keep seed from drying out. Data collected included the germination rate and germination development (white clover only; presence of radicle, 1 leaf cotyledon, 2 leaf cotyledon). A seed was considered germinated once change in the seed was noticed (break in seed coat, radicle emerging). Data were analyzed utilizing SAS 9.2 generalized linear model, with mean separation according to least significant difference test, alpha = 0.05.

Experiment 2 : Effect of Spent Coffee Grounds and Pine Bark on Seed Germination in Containers. Trade gallon containers were filled with Sunshine #1 potting mix to 3 in. below the top of the container and watered accordingly. *Trifolium repens* and *A. palmeri* were overseeded at 15 seed per container (one species per container) and then mulched with either spent coffee grounds (SCG) or pine bark (PB) to a depth of 0, 0.5, 1.0, 1.5, or 3 in. and watered accordingly. Data collected included the number of visible weeds at 3, 6, 10, and 14 days after seeding (DAS). Data were analyzed utilizing SAS 9.2 generalized linear model, with mean separation according to least significant difference test, alpha = 0.05.

RESULTS

Experiment 1. White clover started germinating in all treatments 1 DAS (Table 1) and the 75% ACE had statistically less white clover germinate (22%) compared to the control (17%). At 2 and 4 DAS all ACE-treated dishes had less germination compared to the control. At 5 DAS, all percent ACE treatments had less white clover germination compared to the control with the exception of the 25% ACE treatment. At 6 and 7 DAS all percentage ACE treatments had similar white clover germination compared to the control with the exception of the 100% ACE solution. By 8 DAS nearly all white clover had germinated in all treatments and were statistically similar. While statistically there were no differences in treatments 8 DAS, there were visual differences. As the percentage of ACE increased, the progression of seed growth was less advanced (Table 2). On 9 DAS, 77% of the seed treated with 75% and 100% ACE only had emerged radicles. Only 3% of the seed had 1 or 2 cotyledons in 100% ACE treatment. On the other hand, 14% of the seed were in the 1-leaf-cotyledon stage and 38% in 2-leaf-cotyledon stage for the control.

Perennial rye seed started germinating 4 DAS in the 0%, 25%, and 50% ACE treatments (Table 3). However there were no significant differences regardless of ACE treatments. At 6, 7, and 8 DAS all treatments with ACE had significantly less perennial rye than the control. Number of germinated perennial rye seeds tended to decrease as percentage ACE increased, respectively.

Palmer amaranth treated with higher percentage of ACE had lower seed germination rate than the control (Table 4). However, germinated seeds were short lived, more than likely due to the small seeds being over saturated.

Experiment 2. For white clover there was significantly less seedlings in all treatments with mulch than the control regardless of the depth or type (Table 5). Our results were similar to Sciarappa et al. (2008) who reported that mulching with SCG is an effective weed control option in field blueberry production. Comparing mulch types, 0.5 and 1.0 in. SCG were not significantly different from 0.5 and 1.0 in. PB treatments, respectively. At 14 DAS white clover started emerging in the 1.5-in. PB treatment, however statistically there is no difference compared to the zero emergence in 1.5-in. SCG treatment. No weed emergence was observed in 3-in. mulch 14 DAS. As of 14 DAS only a few of palmer amaranth had only germinated in the 0 in. mulch (data not shown).

DISCUSSION

In conclusion, initial white clover germination was observed in all ACE treatments however development of the seedlings at 8 DAS were different, respectively. These results suggest that ACE might have some properties that inhibit white clover and perennial rye growth. Mulching with either SCG or PB had less seedlings than the non-mulched treatment. Moreover, mulching in containers is a technique used by Oregon growers especially in areas or crops susceptible to herbicide damage (Altland and Lanthier, 2007). Utilizing SCG as mulch in containers can provide an organic alternative to weed control in the nursery industry. These results are ongoing and future research will focus on evaluating container plant growth with SCG mulch and evaluating spent coffee grounds as a weed barrier.

Table 1. Effect of varing concentations of an aqueous coffee extract (ACE) on germination of *Trifolium repens*.

		Germination rate (%)													
Treatment	ACE	1 DAS[z]		2 DAS		4 DAS		5 DAS		6 DAS		7 DAS		8 DAS	
1	0%[y]	17	a[x]	35	a	56	a	60	a	73.2	a	85.2	a	82.4	a
2	25%	10	ab	17	b	36	b	52	ab	61.2	ab	84	ab	80	a
3	50%	8.8	ab	18	b	26	bc	37	bc	58.4	ab	83.2	ab	86.4	a
4	75%	3.2	b	8	b	17	c	26	c	61.6	ab	81.6	ab	83.2	a
5	100%	7.2	ab	13	b	22	c	36	c	44	b	48.8	b	76.8	a

[z]DAS = days after seeding.
[y]Percent ACE stock solution. Stock solution was obtained by mixing 231 g of coffee grounds with 600 mL of water and stirring for 48 hours on a shaker plate.
[x]Means (within a column) with different letters are significantly different, according to Least Significant Difference test (α=0.05).

Table 2. Differences in *Trifolium repens* grown under aqueous coffee extracts (ACE), 9 days after seeding.

		Seed germination development (%)					
Treatment	ACE	Radicle[z]		Cotyledon[y]		Leaf[x]	
1	0%[w]	32.0	b[v]	14.4	a	37.6	a
2	25%	52.0	ab	8.8	ab	27.2	ab
3	50%	64.8	a	12.0	a	12.0	bc
4	75%	76.8	a	8.0	ab	6.4	bc
5	100%	76.8	a	3.2	b	3.2	c

[z]Radicle = only the radicle had emerged.
[y]Cotyledon = 1 leaf cotyledon stage.
[x]Leaf = 2 leaf cotyledon stage.
[w]Percent ACE stock solution. Stock solution was obtained by mixing 231 g of coffee grounds with 600 mL of water and stirring for 48 hours on a shaker plate.
[v]Means (within a column) with different letters are significantly different, according to Least Significant Difference test (α=0.05).

Table 3. Effect of varing concentations of an aqueous coffee extract (ACE) on germination of *Lolium perenne*.

		Germination rate (%)													
Treatment	ACE	1 DAS[z]		2 DAS		4 DAS		5 DAS		6 DAS		7 DAS		8 DAS	
1	0%[y]	-		-		1.6	a[x]	10	a	32	a	42.8	a	52	a
2	25%	-		-		0.8	a	4	a	11.2	b	24	b	28	b
3	50%	-		-		0.8	a	0.8	a	8	b	18.4	bc	28	b
4	75%	-		-		0	a	0	a	3.2	b	10.4	cd	15.2	bc
5	100%	-		-		0	a	0	a	0	b	0.8	d	3.2	c

[z]DAS = days after seeding.
[y]Percent ACE stock solution. Stock solution was obtained by mixing 231 g of coffee grounds with 600 mL of water and stirring for 48 hours on a shaker plate.
[x]Means (within a column) with different letters are significantly different, according to Least Significant Difference test (α=0.05).

Table 4. Effect of varing concentations of an aqueous coffee extract (ACE) on germination of *Amaranthus palmeri*.

		Germination rate (%)													
Treatment	ACE[z]	1 DAS		2 DAS		4 DAS		5 DAS		6 DAS		7 DAS		8 DAS	
1	0%[y]	0.8	a[x]	5.6	a	18	a	27	a	14.4	a[w]	24	ab	20	a
2	25%	1.6	a	5.6	a	8	b	13	b	9.6	a	29.2	a	14.4	a
3	50%	0.8	a	3.2	a	9.6	ab	6.4	b	10.4	a	8.8	ab	7.2	b
4	75%	2.4	a	2.4	a	1.6	b	5.6	b	5.6	a	4	b	8	b
5	100%	3.2	a	2.4	a	4	b	4.8	b	7.2	a	4	b	6.4	b

[z]DAS = days after seeding.

[y]Percent ACE stock solution. Stock solution was obtained by mixing 231 g of coffee grounds with 600 mL of water and stirring for 48 hours on a shaker plate.

[x]Means (within a column) with different letters are significantly different, according to Least Significant Difference test (α=0.05).

[w]Means lower than the value in the previous day was due to seed mortality which may have been caused by over saturation of the seeds.

Table 5. Efficacy of spent coffee grounds (SCG) and pinebark (PB) used as mulch for control of *Trifolium repens*.

	Mulch		Seedling emergence							
Treatment	Depth (inches)	Type	3		6		10		14	
1	0.0	-	2.5	a[z]	7.0	a	7.5	a	9.0	a
2	0.5	SCG	0.8	b	3.0	bc	3.8	bc	4.0	bc
3	1.0	SCG	0.0	b	0.5	d	0.8	de	1.5	de
4	1.5	SCG	0.0	b	0.0	d	0.0	e	0.0	e
5	3.0	SCG	0.0	b	0.0	d	0.0	e	0.0	e
6	0.5	PB	0.5	b	3.8	b	5.3	b	5.8	b
7	1.0	PB	0.0	b	1.3	cd	2.5	cd	2.5	cd
8	1.5	PB	0.0	b	0.0	d	0.0	e	0.3	e
9	3.0	PB	0.0	b	0.0	d	0.0	e	0.0	e

[z]Means (within a column) with different letters are significantly different, according to Least Significant Difference test (α=0.05).

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