Research Reports

The Weed Control Potential of Oat Cultivars

Orion P. Grimmer and
John B. Masiunas¹

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SUMMARY. Winter-killed oats (*Avena sativa*) may have potential for use to suppress weeds in early seeded crops such as pea (*Pisum sativum*). Residue biomass and surface coverage are generally correlated with weed suppression. Oat residues also contain allelochemicals. Our objective was to determine if oat cultivars vary in residue production and allelopathy. Differences between oat cultivars were observed in residue production, and for effects on emergence of common lambsquarters (*Chenopodium album*) and shepherd's-purse (*Capsella bursa-pastoris*) in the greenhouse, and germination of pea and common lambsquarters in an infusion assay. Two of the oat cultivars producing the greatest biomass, 'Blaze' (in the field) and 'Classic' (in the greenhouse), interfered minimally with pea

germination and were among the best cultivars in inhibiting common lambsquarters and shepherd's-purse. 'Blaze' also greatly inhibited common lambsquarters germination in the infusion assay that measured allelopathy. Thus, 'Blaze' and 'Classic' possess suitable characteristics for use as a cover crop preceding peas.

Oat has traditionally been used as a cover crop preceding pea. Oat cultivars have been developed for high grain yield, straw production, and disease resistance. While many of these attributes also contribute to making oat a good cover crop, other attributes that have not been studied—such as high biomass production and high concentration of allelopathic compounds in leaves—are more important for its use as a cover crop.

Oat has several characteristics that make it well suited as a fall planted, winter-killed cover crop in the midwestern United States. Oat is adapted to cool, moist weather and rich soils. Oat is frost tolerant, yet will winter-kill in the central midwestern U.S. (Sustainable Agriculture Network, 1998). Oat does not interfere appreciably with pea, and when oat is intercropped with pea in forage mixes the productivity of the mixture is greater than either species grown alone (Carr et al., 1998; Chapko et al., 1991). Oat also reduces pea root rot (*Aphanomyces euteiches*) (Purdue University, 1999; Williams-Woodward et al., 1997). In a field study in Minnesota, a preceding oat crop increased pea yield by 48% on root rot infested soils compared with a control (Fritz et al., 1995).

Oat, like all small grains, better retains residue over the winter than dicot cover crops (Stivers-Young, 1998).

Oat may, however, decompose faster than some other small grains. This effect is beneficial for releasing nitrogen to the following crop but may limit the length of weed control from oat residues (Malpassi et al., 2000). In an Oklahoma field study, spring-planted oats produced less ground cover than rye (*Secale cereale*) and barley (*Hordeum vulgare*) (Nelson et al., 1991). However, oat cultivars vary in height and straw production [National Small Grains Collection (NSGC), 2002], and identifying oat cultivars with greater biomass production may overcome the problem of less ground cover than other small grains.

Allelochemical content of oats has been investigated since the 1950s (Martin, 1957; Martin and Rademacher, 1960). The allelochemicals scopoletin, coumaric acid, L-tryptophan, *p*-hydroxybenzoic acid, and vanillic acid are exuded from oat roots (Kato-Noguchi et al., 1994a; Martin and Rademacher, 1960). Mature oat leaf tissue contains coumaric, ferulic, *p*-hydroxybenzoic, syringic, and vanillic acids that are allelopathic (Guenzi and McCalla, 1966). Young oat shoots contain L-tryptophan at a concentration of 12 mg·kg⁻¹ (ppm) on a dry weight basis. This concentration was high enough to inhibit radical elongation by greater than 50% in cockscorn (*Amaranthus caudatus*), cress (*Lepidium sativum*), and lettuce (*Lactuca sativum*) but was not high enough to inhibit timothy (*Phleum pratense*), rice (*Oryza sativa*), wheat (*Triticum aestivum*), or oat by greater than 50% (Kato-Noguchi et al., 1994b).

Cultivar differences in allelopathic compound production have been investigated for the root-exuded compound scopoletin (Fay and Duke, 1977). In a sand polyculture, one oat cultivar, 'PI 255281', inhibited wild mustard (*Brassica kaber* var. *pinnatifida*) growth more than a standard commercial cultivar. In soil, however, no differences were observed. Fay and Duke (1977) suggested that scopoletin might be decomposed by soil organisms or bound by the soil.

Thus, oat cultivars vary in their ability to produce biomass and in their range and concentration of allelochemicals (Fay and Duke, 1977; NSGC, 2002). It may be possible to identify oat cultivars that minimally affect pea growth but control important cool season weeds such as common

Department of Natural Resources and Environmental Sciences, University of Illinois, 260 Edward R. Madigan Laboratory, 1201 W. Gregory Dr., Urbana, IL 61801.

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¹To whom reprint requests should be addressed. E-mail address: masiunas@uiuc.edu

lambsquarters and shepherd's-purse (Fay and Duke, 1977; Kato-Noguchi et al., 1994b).

The objective of this study was to identify oat cultivars that produce a large biomass and suppress weeds without injuring pea. Three sets of studies were conducted to accomplish this objective. The field study determined biomass production of fall-planted oats. The greenhouse study evaluated the ability of oat residues to suppress emergence of common lambsquarters and shepherd's-purse without affecting pea. The growth chamber study determined if oat infusions, which likely contained allelochemicals, suppressed common lambsquarters germination without affecting pea.

Materials and methods

FIELD STUDY. Our objective was to determine the growth and biomass production of fall-planted oat cultivars. Other studies have correlated cover crop biomass production with weed suppression (Teasdale, 1993). Nineteen commercially available oat cultivars ('Blaze', 'Brawn', 'Cayuse', 'Chaps', 'Classic', 'Dane', 'Drumlin', 'Gem', 'Ida', 'Jay', 'Jerry', 'Jim', 'Ogle', 'Prairie', 'Rodeo', 'Ruby', 'Sequi', 'Vista', and 'Wabasha') and two commercial barley cultivars ('Spring' and 'UC-603') were planted on 31 Aug. 2002 at the Cruise Tract Irrigated Vegetable Research Farm in Champaign County (east central Illinois) and on 30 Sept. 2002 at the Dixon Springs Agricultural Research Center in Pope County (southern Illinois). 'Cayuse' oat and 'UC-603' barley were provided by Peaceful Valley Farm Supply (Grass Valley, Calif.). All other cultivars were provided by the University of Illinois small grains breeding program, courtesy of F. Kolb. The two barley cultivars were included for comparison with the oat cultivars. The soil types were Flanagan silt-loam (fine montmorillonitic, mesic, Aquic Arguidoll) at Champaign and Grantsburg silt loam (fine-silty, mixed, mesic Typic Fragiudall) at Dixon Springs. The experiment was a randomized complete-block design with three replications at each location. Location was included in the analysis to determine how oat cultivar growth was affected by environment.

The experimental unit consisted of a plot 61.0 × 61.0 cm (0.37 m²) [24 × 24 inches (4.0 ft²)] containing three rows spaced 20 cm (7.9 inches)

apart. The plots were seeded by hand with the seeds planted at a depth of 2.5 cm (1 inch), at a seeding rate of approximately 100.9 kg·ha⁻¹ (90 lb/acre) for oats and 134.5 kg·ha⁻¹ (120 lb/acre) for barley. No supplemental weed control was provided.

At the end of the fall growing season, when minimum daily temperatures dropped to approximately -7 °C (19.4 °F), the average height of the small grain was recorded and the shoots harvested by cutting at the soil surface. Harvest occurred on 5 Dec. 2002 (96 DAP) at Champaign and 16 Dec. 2003 (77 DAP) at Dixon Springs. Fresh weight of the shoots was determined in the field. The shoots were oven-dried at 93 °C (199.4 °F) for 48 h and dry weight determined. This study allowed us to determine

oat biomass production but did not determine suppression of common lambsquarters and shepherd's-purse.

GREENHOUSE STUDY. Two studies were conducted in the Plant Sciences Laboratory Greenhouses on the University of Illinois campus. The first study confirmed oat cultivar biomass production observed in the field study. The second study quantified the effects of oat cultivar residues on emergence and growth of common lambsquarters, shepherd's-purse, and pea.

In the first study, 24 oat cultivars consisting of the same 19 oat cultivars from the field study plus five additional oat cultivars ('53-6', 'C.I.V. 350', 'Lokhovsky', 'Minnesota 12008', and 'Red Algerian') from NSGC (NSGC, 2002) were used (Table 1). Five barley cultivars were also included, the

Table 1. Oat cultivar affects on shoot dry weight in field and greenhouse studies.

Cultivar	Species	Commercial source ^z	Field study	Greenhouse study
			----- Shoot dry wt ----- (kg·ha ⁻¹) ^y	
Sequi	Oat	Albert Lea Seed	4660 a ^x	1390 a
Blaze	Oat	Wilken Seed	4380 ab	1200 c-f
Rodeo	Oat	Manning Agr.	3390 a-c	1050 e-i
Vista	Oat	Kuehl Seed	3590 a-c	1430 b-e
Jim	Oat	Welter Seed	3530 a-d	1150 d-h
Chaps	Oat	Naylor Seed	3550 a-d	977 f-i
Cayuse	Oat	Peaceful Valley	3210 cd	1100 d-h
Jerry	Oat	Naylor Seed	3050 cd	1360 ab
Wabasha	Oat	Welter Seed	3630 cd	1150 d-h
53-6	Oat	NSGC/ Peru	---	1330 d-i
Minnesota 12008	Oat	NSGC/Minnesota	---	1020 d-i
Ida	Oat	Welter Seed	2970 c-e	1190 c-f
Classic	Oat	Ill. Crop Improve	2910 c-e	1310 a-c
Jay	Oat	Wilken Seed	2900 c-e	1200 b-e
Ruby	Oat	UI	3380 c-e	1130 d-h
Gem	Oat	Naylor Seed	2810 c-e	1040 e-i
Ogle	Oat	Wilken Seed	3040 c-e	1220 b-d
Prairie	Oat	UI	3200 c-e	1160 c-f
Drumlin	Oat	Kuehl Seed	2670 d-f	1160 d-f
Red Algerian	Oat	NSGC/Algeria	---	1210 d-g
Dane	Oat	Naylor Seed	2320 ef	1200 b-e
Brawn	Oat	Cunningham Seed	2330 f	1330 b-e
Lokhovsky	Oat	NSGC/Germany	---	1250 g-j
C.I.V. 350	Oat	Peaceful Valley	---	1070 h-j
UC-603	Barley	Peaceful Valley	3510 b-d	1020 f-i
Spring	Barley	FS	3900 b-d	1100 d-h
Chiho 6440	Barley	NSGC/Poland	---	1360 b-e
661A	Barley	NSGC/ Switzerland	---	1330 ij
674F	Barley	NSGC/Switzerland	---	1240 j

^zAlbert Lea Seed = Albert Lea Seed House, Albert Lea, Minn.; Cunningham Seed = Cunningham Seed Farms, Sleepy Eye, Minn.; Ill. Crop Improve = Illinois Crop Improvement Assn., Champaign; Kuehl Seed = Kuehl Seed Farm, Kewaunee, Wis.; Manning Agr. = Manning Agricultural Center, Manning, Iowa; Naylor Seed = Naylor Seed Co., Scotch Grove, Iowa; NSGC/Location = National Small Grains Collection, USDA-ARS, Aberdeen, Idaho/location of origin; Peaceful Valley = Peaceful Valley Farm Supply, Grass Valley, Calif.; UI = Fred Kolb, University of Illinois Small Grains Breeding Program, Urbana; Welter Seed = Welter Seed and Honey Co., Onslow, Iowa.

^y1 kg·ha⁻¹ = 0.89 lb/acre.

^zMeans within study with the same letter are not significantly different according to Fisher's protected least significant difference (LSD) at *P* ≤ 0.05.

two barley cultivars used in the field experiment plus three additional barley cultivars—‘661A’, ‘674F’, and ‘Ciho 6440’—from NSGC. These additional oat and barley cultivars were selected by searching the NSGC database for oat cultivars with high straw production and barley cultivars with tall growth habit (barley straw production is not characterized in the NSGC database) that were not already included in our study. Oat and barley were planted at 100.9 kg·ha⁻¹ seed (12 seeds oat or 11 seed barley per pot) into 20-cm-diameter pots filled with an 1:1 mixture of Drummer silty-clay-loam soil to coarse sand.

The experiment was a randomized complete-block design with five replications. The experiment was conducted three times. Repeats were conducted under natural daylight from 11 Nov. to 19 Dec. 2002 (43 d); 26 Feb. to 1 Apr. 2003 (34 d), and 3 Apr. to 15 May 2003 (42 d). Twelve-hour day and night set temperatures were 25 and 22 °C (77.0 and 71.6 °F), respectively. The soil was kept moist daily with 1 to 2 cm (0.39 to 0.79 inch) overhead watering. The pots [surface area = 314 cm² (48.7 inch²), volume = 7850 cm³ (479.0 inch³)] were fertilized approximately 1 week after planting with Peter's Professional All-Purpose Plant Food (Scotts-Sierra, Marysville, Ohio) at 0.47 g/pot (0.017 oz/pot) nitrogen, phosphorus, and potassium; 2.36 mg/pot chelated iron; 1.26 mg/pot magnesium; 1.26 mg/pot chelated copper, manganese, and zinc; and 0.0126 mg/pot molybdenum (28,350 mg = 1 oz).

When the first cultivar began to bolt, the oats were harvested and the number of shoots, the height from the soil to the tip of the tallest shoot, and the fresh weight of the shoots were determined. Shoots were oven dried at 93 °C for 48 h and dry weight determined.

The second greenhouse study evaluated the effect of field-grown residue from 19 commercially available oat cultivars and one barley cultivar (‘Spring’) on the germination and growth of ‘Mega’ pea (Territorial Seed Co., Cottage Grove, Ore.), common lambsquarters, and shepherd's-purse. Common lambsquarters and shepherd's-purse were chosen because they were the most common cool season weeds at both field sites. Common lambsquarters and shepherd's-purse

seeds were purchased from Valley Seed Service (Fresno, Calif).

Pots of pea, common lambsquarters, and shepherd's-purse were independently randomized, physically separate, and analyzed separately. There were three repeats, each arranged in a randomized complete-block design with four replications. Repeats for pea were conducted from 9 Jan. to 11 Feb. (33 d), 3 Feb. to 7 Mar. (32 d), and 9 Apr. to 15 May 2003 (36 d). Repeats for common lambsquarters and shepherd's-purse were conducted from 9 Jan. to 11 Feb. (33 d), 24 Jan. to 28 Feb. (35 d), and 18 Feb. to 25 Mar. 2003 (35 d). At termination, pea had approximately eight leaves, and common lambsquarters and shepherd's-purse had one pair of fully expanded true leaves. Light was provided by natural daylight; 12-h day and night set temperatures were 25 and 22 °C, respectively. The soil was kept moist daily with 1 to 2 cm of overhead watering. No fertilization occurred.

Six pea seeds were planted 1.5 cm (0.59 inch) deep into 18-cell flats; each cell was filled with 300 cm³ (18.3 inch³) of an 1:1 mixture of Drummer silty-clay-loam soil and coarse sand to 1 cm below the rim. With common lambsquarters and shepherd's-purse, approximately 50 seeds of the appropriate species were applied to the soil surface of 32-cell flats; each cell was filled with 180 cm³ (11.0 inch³) soil mix to 1 cm below the rim. Fifty seeds were approximated by 21.6 mg common lambsquarters seeds and by 5.0 mg shepherd's-purse seeds. These weights were the average of seven lots of 50 randomly selected seeds.

After seeding the three test species, cover crop residue was applied to the soil surface at a dry weight rate corresponding to 4000 kg·ha⁻¹ (3569 lb/acre), covering the weed seeds. The study used fall-harvested residue from the field study that had been oven dried at 93 °C for 48 h. Residue from all replications and both locations was combined and hand mixed. Methodology was similar to that used by Teasdale (1993). A bare-soil control was included for comparison.

When the experiment was terminated, the number of pea seedlings, pea shoot fresh weight, and the height of the tallest pea shoot in each cell were determined. Shoots were oven dried at 93 °C for 48 h and dry weight was determined. For common lambsquarters

and shepherd's-purse, emerged weed seedlings were counted and fresh weight of the weed seedlings was determined. Because the shoots were small, dry weight was not determined. This study provided an indication of the ability of oat residues to suppress common lambsquarters and shepherd's-purse but did not indicate the mechanism of this suppression.

INFUSION BIOASSAY. A study was conducted to evaluate the effects of infusions made from the residues of the 24 oat cultivars grown in the greenhouse on the germination of pea (cv. Mega) and common lambsquarters. Shepherd's-purse did not germinate well in the infusion experiment, so it was not included. Based on previous studies, this infusion was assumed to contain water-soluble allelochemicals and allowed us to separate physical or environmental effects of the cover crop residues from allelochemical effects (Guenzi and McCalla, 1966; Kato-Noguchi et al., 1994a, 1994b).

Infusions were made with 7.2 g (0.254 oz) of residue from each oat cultivar; this was the maximum amount of residue that could be covered by 100 mL (3.38 fl oz) water. The residues were placed in 100-mL deionized water for 5 h in a dark growth chamber at 30 °C (86.0 °F). The infusion was separated from the residue by passing the liquid twice through a screen with 1-cm² (0.16 inch²) openings. The control was deionized water with no oat infusion. The treatment (oat cultivar) was arranged in a completely randomized design with five replications. The study was repeated.

Twenty pea seeds were placed with 20 mL (0.68 fl oz) oat infusion in 100-mL glass jars with plastic caps. For 5 h while the pea imbibed the infusion, the jars were placed in a dark growth chamber maintained at 30 °C. Then the infusion was drained, the seeds were rinsed with deionized water, and the jars with the pea seeds were returned to the growth chamber. Every 24 h, the jars were removed from the growth chamber and deionized water added to maintain moisture of the peas. For this portion of the incubation, the dark growth chamber had temperatures alternating between 25 and 30 °C every 12 h. At 48 and 96 h, the numbers of germinated seeds were determined.

To determine the effect of oat infusions on common lambsquarters we used a procedure modified from

Kato-Noguchi et al. (1994a) and Haugland and Brandsaeter (1996). Fifty seeds of common lambsquarters were placed upon accordion-folded three-layer brown-paper towel [8 × 12 cm (3.1 × 4.7 inches)] in 9-cm-square (3.5 inches) petri dishes and 7 mL (0.24 fl oz) of the previously described infusion was added. The petri dishes were enclosed in polyethylene bags and placed in the growth chamber with a 12-h light/dark cycle. The day/night temperatures were 30/25 °C. At 2, 4, and 9 d after initiation, the petri dishes were opened and germinated seedlings were counted and removed. The paper towels were remoistened at 2 and 4 d with 7 mL of infusion.

In all the studies, data were analyzed using SAS (SAS Institute, 2000). Analysis of variance was conducted using the MIXED procedure. When necessary, data were transformed so that the residuals were normal by the Shapiro-Wilks test ($P \geq 0.005$, fail to reject H_0 = residuals are normal) in the UNIVARIATE procedure. Means were separated using Fishers protected least significant difference at the 0.05 level.

Results and discussion

In the field study, the location × cultivar interaction was insignificant ($P = 0.7035$). The main effects of location ($P < 0.0001$) and cultivar ($P = 0.0003$) were significant. Fewer residues were produced at Dixon Springs compared with Champaign, possibly due to a later planting and thus a shorter growing season at Dixon Springs. Averaged over location, the highest biomass yielding oat cultivars were ‘Sequi’, ‘Blaze’, ‘Rodeo’, ‘Vista’, ‘Jim’, and ‘Chaps’ (Table 1). The two barley cultivars, ‘UC-603’ and ‘Spring’, yielded less than ‘Sequi’ but similar to ‘Blaze’, the second-highest yielding oat cultivar.

In the greenhouse, the effect of cultivar was significant ($P < 0.0001$) on oat shoot biomass. The highest yielding cultivar was once again ‘Sequi’ (Table 1). The cultivars Jerry and Classic had similar biomass as ‘Sequi’. These cultivars were among the lower third in biomass production in the field. Different growing conditions in the greenhouse and the field may have contributed to different results in the two studies.

In the second greenhouse study, the residues from the cover crop cultivars did not affect pea emergence rate ($P = 0.1575$), height ($P = 0.5962$), or

dry weight ($P = 0.6605$). Therefore, the presence or absence of oat or barley residue did not influence the emergence and growth of pea. This suggests that oat cover crops may not significantly harm pea in the field.

The oat cultivar main effect influenced common lambsquarters emergence ($P = 0.0012$) but not fresh weight ($P = 0.7533$). Common lambsquarters emergence in the bare soil control was greater than in the cover crop treatments (maximum 48% of control, Table 2). Common lambsquarters emergence was greater in residues of the oat cultivar ‘Blaze’ than in residues of ‘Ruby’ and ‘Vista’; emergence in residues of other cultivars did not differ among each other. Common lambsquarters seedlings had great variability in size from pot-to-pot between replications, which obscured treatment effects.

Common lambsquarters suppression by oat and barley residue in our experiment was similar to common lambsquarters suppression by hairy vetch (*Vicia villosa*) in a field study in New York and Maryland (Teasdale,

1996). Hairy vetch at 3200 kg·ha⁻¹ (2855 lb/acre) reduced common lambsquarters emergence by 66%. In this experiment, oat and barley residues at 4000 kg·ha⁻¹ reduced common lambsquarters emergence by 52% to 74%.

Oat cultivars affected shepherd’s-purse emergence ($P < 0.0001$) and fresh weight ($P < 0.0001$). Oat residue suppressed emergence to less than 24% and fresh weight to less than 17% of the control (Table 2). The oat cultivars ‘Brawn’, ‘Classic’, ‘Dane’, ‘Drumlin’, ‘Gem’, ‘Ida’, ‘Ogle’, ‘Prairie’, ‘Ruby’, ‘Wabasha’, and ‘Rodeo’ and the barley cultivar ‘Spring’ were the best at suppressing shepherd’s-purse emergence and fresh weight.

In the oat infusion study, the oat cultivar influenced germination of pea ($P = 0.0024$) and common lambsquarters ($P = 0.0117$). Pea germination in deionized water was similar to germination in infusions from ‘Blaze’, ‘Chaps’, ‘C.I.V. 350’, ‘Dane’, ‘Lokhovskiy’, ‘Prairie’, ‘Red Algerian’, and ‘Vista’ (Table 2). Infusions from other culti-

Table 2. Oat and barley residue affects on emergence of common lambsquarters (CHEAL) and shepherd’s-purse (CAPBU), and fresh weight of shepherd’s-purse in the greenhouse study and germination of lambsquarters and pea in the infusion study.

Cultivar	Greenhouse study			Germination in infusion study	
	Emergence		Fresh wt		
	CHEAL	CAPBU	CAPBU	CHEAL	Pea
	----- (% control) ^z -----				
Control	100 a ^z	100 a	100 a	100 a	100 a
Blaze	47 b	24 b	17 b-d	41 c-e	73 a-e
Jim	40 bc	24 bc	21 b	35 de	54 c-h
Rodeo	37 bc	19 b-d	15.1 b-i	24 de	38 e-h
Jerry	48 bc	15 b-e	17 b-h	38 de	35 gh
Vista	27 c	19 b-e	14 b-g	79 a-c	72 a-c
Jay	37 bc	19 b-e	9 b-e	48 c-e	43 c-h
Chaps	32 bc	17 b-f	17 b-f	48 c-e	74 a-d
Sequi	38 bc	19 b-f	23 bc	52 b-e	60 b-h
Cayuse	43 bc	14 b-f	8.8 b-e	62 a-d	53 c-h
Wabasha	38 bc	15 b-g	2.8 d-i	79 a-c	59 b-h
Prairie	34 bc	11 b-g	5.4 c-i	45 c-e	69 a-g
Ogle	33 bc	14 b-g	18 b-i	48 c-e	35 gh
Ida	29 bc	9.0 c-g	1.4 e-i	90 ab	41 d-h
Brawn	36 bc	10 d-g	4.9 f-i	38 de	37 f-h
Dane	36 bc	9.0 d-g	17 b-i	31 de	91 ab
Classic	27 bc	11 d-g	17 b-i	31 de	56 c-h
Ruby	26 c	5.6 e-g	0.9 g-i	14 e	29 h
Gem	32 bc	5.6 e-g	0.0 i	45 c-e	65 b-g
Drumlin	34 bc	2.3 g	0.6 hi	52 b-e	43 c-h
Spring Barley	33.0 bc	4.5 fg	1.7 e-i	---	---

^zPercent emergence, percent fresh weight, and percent germination were all relative to control. In the greenhouse study, common lambsquarters had 26% emergence; shepherd’s-purse had 15% emergence and 292 g (10.3 oz) fresh weight in the control. In the infusion study, common lambsquarters and pea had 15% and 63% germination, respectively, in the control.

^yMeans within study with the same letter are not significantly different according to Fisher’s protected least significant difference (LSD) at $P \leq 0.05$.

vars inhibited pea germination, probably due to the presence of allelochemicals. For common lambsquarters, the cultivars Ida, Vista, Wabasha, Cayuse, and 53-6 suppressed germination less than the most suppressive cultivar, 'Rudy' (Table 2). 'Ida', 'Vista', 'Wabasha', and 'Cayuse' did not suppress common lambsquarters germination compared with deionized water.

The optimal oat cultivar for use in a pea production system should suppress weeds while minimally affecting pea. Because higher residue levels of other cover crops have been strongly correlated with better weed control (Teasdale, 1996), the best oat cultivars are likely to be those producing the greatest biomass (e.g. 'Sequi', 'Blaze', 'Rodeo', 'Jim', 'Vista', 'Chaps', 'Jerry', and 'Classic'). Of these cultivars, 'Sequi' was the only one to produce high residues in both the field and the greenhouse. However, 'Sequi', 'Rodeo', and 'Jim' did not suppress common lambsquarters and shepherd's-purse in the greenhouse. 'Vista' was inconsistent in suppressing these weeds, and 'Chaps' and 'Jerry' inhibited pea germination in the infusion assay.

One additional oat cultivar, 'Dane', deserves further investigation. 'Dane' was among the best cultivars for inhibiting common lambsquarters and shepherd's-purse and did not injure pea. Unfortunately, 'Dane' produced among the least residue in the field and greenhouse. Under different growing conditions, 'Dane' may produce more residues.

Overall, 'Blaze' and 'Classic' were the most promising oat cover crop cultivars. 'Blaze' suppressed weeds well in the infusion experiments and did not inhibit pea. 'Classic', while producing high residue in the greenhouse and not in the field, was consistently among the best cultivars in inhibiting weeds.

Different responses were observed in the emergence of pea and common lambsquarters plants in the greenhouse residue study compared to their seed germination in the infusion studies. For pea, the residues did not affect emergence in the greenhouse study, but germination was affected in the infusion study. Soil, present in the greenhouse study, may have bound the allelochemicals making them unavailable to inhibit peas (Fay and Duke, 1977). In addition, the residues for the greenhouse study were grown in the

field and the residues for the infusion study were grown in the greenhouse. This may have affected allelochemical content. In the greenhouse, the glass blocks ultraviolet light, which may be required for the production of some allelochemicals (Putnam, 1985).

While these experiments did not attempt to isolate and quantify allelochemicals, they did show differences in oat cultivar allelopathic potential similar to those observed in previous research with oats (Fay and Duke, 1977) and rye (Wahle, 1996). Our results demonstrated that some oat cultivars—for example, 'Blaze' and 'Classic'—could be good at suppressing weeds while not inhibiting pea. Two allelochemicals found in oat, scopoletin and L-tryptophan, have been shown to selectively affect different species (Fay and Duke, 1977; Kato-Noguchi et al., 1994b). This could be an explanation for the differential response of common lambsquarters and peas. Further research is needed to characterize the reason for this selectivity.

Literature cited

- Carr, P.M., G.B. Martin, J.S. Caton, and W. Poland. 1998. Forage and nitrogen yield of barley-pea and oat-pea intercrops. *Agron. J.* 90:79–84.
- Chapko, L.B., M.A. Brinkman, and K.A. Albrecht. 1991. Oat, oat-pea, barley, and barley-pea for forage yield, forage quality, and alfalfa establishment. *J. Prod. Agr.* 4:486–491.
- Fay, P.K. and W.B. Duke. 1977. An assessment of allelopathic potential in *Avena* germplasm. *Weed Sci.* 25:224–228.
- Fritz, V.A., R.R. Allmaras, F.L. Pfleger, and D.W. Davis. 1995. Oat residue and soil compaction influences on common root rot (*Aphanomyces euteiches*) of peas in a fine-textured soil. *Plant Soil* 171:235–244.
- Guenzi, W.D. and T.M. McCalla. 1966. Phenolic acids in oat, wheat, sorghum, and corn residues and their phytotoxicity. *Agron. J.* 59:163–165.
- Haugland, E. and L.O. Brandsaeter. 1996. Experiments on bioassay sensitivity in the study of allelopathy. *J. Chem. Ecol.* 22:1845–1849.
- Kato-Noguchi, H., S. Kosemura, S. Yamamura, J. Mitzutani, and K. Hasegawa. 1994a. Allelopathy of oats. I. Assessment of allelopathic potential of extract of oat shoots and identification of an allelochemical. *J. Chem. Ecol.* 20:309–314.
- Kato-Noguchi, H., J. Mitzutani, and K. Hasegawa. 1994b. Allelopathy of oats. II. Allelochemical effect of L-tryptophan and its concentration in oat root exudates. *J. Chem. Ecol.* 20:315–319.
- Malpassi, R.N., T.C. Kaspar, T.B. Parkin, C.A. Cambardella, and N.A. Nubel. 2000. Oat and rye root decomposition effects on nitrogen mineralization. *Soil Sci. Soc. Amer. J.* 64:208–215.
- Martin, P. 1957. The secretion of organic compounds, especially scopoletin, from the roots of oat seedlings. *Zeitschrift für Botanica* 45:475–506.
- Martin, P. and B. Rademacher. 1960. Studies on the mutual influences of weeds and crops. *Br. Ecol. Soc. Symp.* 1:143–152.
- Nelson, W.A., B.A. Kahn, and B.W. Roberts. 1991. Screening cover crops for use in conservation tillage systems for vegetables following spring plowing. *HortScience* 26:860–862.
- National Small Grains Collection. 2002. The small grain collection. U.S. Dept. Agr., Agr. Res. Serv., Aberdeen, Idaho. 5 Apr. 2003. <<http://www.ars-grin.gov/ars/PacWest/Aberdeen/nsgc.html>>.
- Purdue University. 1999. Midwest vegetable production guide for commercial growers. Purdue Univ. Coop. Ext., West Lafayette, Ind.
- Putnam, A.R. 1985. Weed allelopathy, p. 131–155. In: S.O. Duke (ed.). *Weed physiology*. Vol. 1. Reproduction and ecophysiology. CRC Press, Boca Raton, Fla.
- Sustainable Agriculture Network. 1998. Managing cover crops profitably. 2nd ed. Sustainable Agr. Network, Natl. Agr. Library, Beltsville, Md.
- SAS Institute. 2000. SAS user's guide. Version. 8. SAS Inst., Cary, N.C.
- Stivers-Young, L. 1998. Growth, nitrogen accumulation, and weed suppression by fall cover crops following early harvest of vegetables. *HortScience* 33:60–63.
- Teasdale, J.R. 1993. Interaction of light, soil moisture, and temperature with weed suppression by hairy vetch residue. *Weed Sci.* 41:46–51.
- Teasdale, J.R. 1996. Contribution of cover crops to weed management in sustainable agriculture systems. *J. Prod. Agr.* 9:475–479.
- Wahle, E.A. 1996. Optimization of rye (*Secale cereale*) cover cropping systems for vegetable crop production. M.S. Thesis, Univ. of Illinois, Urbana-Champaign.
- Williams-Woodward, J.L., F.L. Pfleger, V.A. Fritz, and R.R. Allmaras. 1997. Green manures of oat, rape, and sweet corn for reducing common root rot in pea (*Pisum sativum*) caused by *Aphanomyces euteiches*. *Plant Soil* 188:43–48.