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Allelopathic Potential of Wheat (*Triticum aestivum*) Straw on Selected Weed Species[1]

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Abstract. **The allelopathic potential of wheat [*Triticum aestivum* (L.) 'Doublecrop'] straw residue was evaluated on weed-seed germination and seedling growth. The inhibition of weed-seed germination and seedling growth was extract-, species-, and temperature-dependent. The extracts prepared by agitating and soaking caused greater inhibition than those obtained by leaching. The descending order of species susceptibility was ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.], velvetleaf (*Abutilon theophrasti* Medic.), pitted morningglory (*Ipomoea lacunosa* L.), hemp sesbania [*Sesbania exaltata* (Raf.) Cory], sicklepod (*Cassia obtusifolia* L.), and Japanese barnyard millet [*Echinochloa crus-galli* var. *frumetaceae* (Roxb.) Link]. Incubation at 35 C caused the greatest inhibition of germination and growth.** *Additional index words.* **Seed germination, germination temperature, phytotoxicity, seedling growth.**

INTRODUCTION

Many crop residues, including wheat straw, contain allelopathic compounds (4, 6, 11). These compounds are thought to enter the environment through volatilization, leaching, or plant decay (9, 10). At present, most of the allelopathic activity has been identified with the effects of weeds on crops and of crops on crops; however, an important economic potential of allelopathy may be the ability of crops to suppress weeds (7).

Wild types of crop species with more allelopathic potential than domestic cultivars have been identified in cucumber (*Cucumis sativus* L.) (8) and oat (*Avena sativa* L.) (3) accessions. LeTourneau et al. (6) determined that water extracts of 23 weed and crop species inhibited germination and growth of wheat seedlings. Cox[3] noted that cold water extracts of wheat and oat straw could reduce soybean [*Glycine max* (L.) Merr.] growth.

Guenzi and McCalla (4) quantitatively determined five phenolic acids contained in wheat residue. Of the five, *p*-coumaric acid was present in the greatest concentration and could influence plant growth. Weed control resulting from allelopathic activity of wheat-straw residue would be particularly valuable in no-tillage, double-cropped soybeans following a small grain crop, where weed problems are noticeably intensified (13).

The objectives of this study were to evaluate the effect of the phytotoxic compounds leached from wheat straw on selected weed species, the effect of temperature on the toxicity of these compounds, and the ability of simulated rainfall to remove these toxins from wheat straw residue.

MATERIALS AND METHODS

Freshly-harvested wheat straw was shredded into 5- to 15-mm lengths with a hammer mill before extraction. Straw extracts were prepared as follows: (a) leached extract – straw (8 g) was placed on a 10- by 13.3-cm screen with a 1-mm mesh (this amount of straw would be equivalent to the residue left on the soil surface from a wheat crop in Arkansas yielding 3360 kg/ha), 170 ml of distilled water was sprinkled over the straw surface to simulate a 1.25-cm rainfall, and the leachate was collected as it passed through the straw layer; (b) soaked extract – straw (14 g) was placed in a 500-ml erlenmeyer flask with 295 ml of distilled water (straw:water ratio as for leached extract) and allowed to sit at room temperature undisturbed for 2 h; (c) agitated extract – this extract was prepared exactly as the soaked extract except the straw:water mixture was agitated for 2 h on a horizontal shaker. All three extracts were filtered through glass wool. The weed species for bioassay were pitted morningglory, ivyleaf morningglory, hemp sesbania, sicklepod, Japanese barnyard millet, and velvetleaf. Ten milliliters of straw extract or of distilled water was added to a series of filter paper-lined petri plates containing 20 seed of each weed species. The petri plates were covered and placed in incubators at 25, 30, and 35 C. After 48 and 96 h, germination (measured as a percentage of the distilled water controls) and mean seedling length (root + shoot) were recorded.

The experimental design was a split-split-plot with the main plot being time, the subplot being incubation temperatures, and the sub-sub-plot being a two-way factorial of straw extracts and weed species. An arcsine transformation was performed on the percent germination values to correct for kurtosis. The experiment was conducted twice with four replications/experiment, and data from both tests were pooled. Data were subjected to analysis of variance, and a Waller Duncan least significant difference test (BLSD) was used to compare means at the 95% confidence level.

RESULTS AND DISCUSSION

Agitated and soaked extracts were most inhibitory to weed seed germination and seedling growth (Tables 1 and 2). The data indicated a significant interaction among extracts, incubation temperatures, and weed species. There were no significant differences in germination and plant growth between incubation times, and data were averaged over both times. The degree of toxicity of the extracts was dependent on both species and incubation temperature. Greater inhibi-

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[3] Cox, R. W. 1977. Factors affecting the growth and yield of double-cropped soybeans. M.S. thesis, Univ. of Arkansas, Fayetteville. 102 pp.

Table 1. Effect of soaked, agitated, and leached wheat-straw extracts and different temperatures on weed germination.

Weed species	Temp.	Germination[a] Water	Wheat-straw extract Soaked	Agitated	Leached
	(C)	(%)			
Hemp sesbania	25	100	96	100	94
	30	100	96	96	94
	35	100	93	90	92
Ivyleaf morningglory	25	100	96	82	91
	30	100	84	82	97
	35	100	7	5	78
Japanese barnyard millet	25	100	91	92	94
	30	100	92	91	99
	35	100	91	93	97
Pitted morningglory	25	100	96	88	94
	30	100	86	90	91
	35	100	47	37	91
Sicklepod	25	100	97	97	96
	30	100	99	98	97
	35	100	86	88	93
Velvetleaf	25	100	68	72	63
	30	100	86	82	88
	35	100	64	65	88
		BLSD (5%)	9		

[a]Percent germination compared to the distilled water control.

Table 2. Effect of soaked, agitated, and leached wheat-straw extracts and different temperatures on seedling length.

Weed species	Temp.	Seedling length[a] Water	Wheat straw extract Soaked	Agitated	Leached
	(C)	(mm)			
Hemp sesbania	25	67	66	54	53
	30	74	67	68	77
	35	94	69	69	92
Ivyleaf morningglory	25	88	42	44	69
	30	87	41	38	86
	35	54	1	1	40
Japanese barnyard millet	25	52	54	49	45
	30	64	62	62	66
	35	79	70	72	80
Pitted morningglory	25	66	58	40	52
	30	62	51	56	65
	35	67	32	34	57
Sicklepod	25	52	49	43	44
	30	64	60	50	60
	35	68	47	51	65
Velvetleaf	25	15	13	7	7
	30	47	11	7	42
	35	27	1	1	19
		BLSD (5%)	11		

[a]Shoot and root length.

tion of germination and growth occurred at 35 C than at 25 or 30 C.

Ivyleaf morningglory germinations was inhibited most (Table 1). Germination of this species was most inhibited by the agitated extract at 25 C, and in comparison with other species, ivyleaf morningglory was the one most inhibited when seeds were incubated at 35 C in the agitated and soaked extracts. Velvetleaf germination was inhibited by all three extracts, with the greatest reduction occurring in the soaked and agitated extracts at 25 and 35 C. Germination of pitted morningglory seed was strongly inhibited at 35 C by the agitated and soaked extracts. Japanese barnyard millet and hemp sesbania seed germination were most tolerant to the wheat-straw extracts.

Growth of ivyleaf morningglory and velvetleaf seedlings was inhibited most by the wheat-straw extracts (Table 2). Ivyleaf morningglory growth was inhibited at all temperatures with all extracts except for the leached extract at 30 C. The greatest growth reduction occurred at 35 C. Velvetleaf growth was reduced at both 30 and 35 C in the soaked and agitated extracts. At 35 C the growth of hemp sesbania, pitted morningglory, and sicklepod was inhibited by the soaked and agitated extracts. At 25 C the leached extract partially inhibited growth of hemp sesbania, ivyleaf, and pitted morningglory. Japanese barnyard millet was the most tolerant species to the wheat-straw extracts.

The similarity in level of inhibition by the agitated and soaked extracts indicate that agitation is not required to remove the toxins from wheat straw. Thus, these toxins could be leached from wheat-straw residue into the soil by rainfall, especially on poorly drained soils. Other researchers (4, 6) have also found water-soluble toxins in wheat straw[3]. Thilsted and Murray (12), in their study of weed control in no-tillage, double-cropped soybeans, found that pigweed (*Amaranthus* spp.) control in untreated straw-mulched plots was approximately equivalent to that obtained with herbicides in straw-mulched and bare-soil plots. Banks and Robinson (1) also noted that a straw mulch suppressed the growth of spiny amaranth (*Amaranthus spinosus* L.), tall morningglory [*Ipomoea purpurea* (L.) Roth], and volunteer wheat more than herbicides used on non-mulched areas. Guenzi et al. (5), however, found that wheat residues essentially contained no water-soluble toxic components after 8 weeks of exposure to field environmental conditions.

Guenzi et al. (5) have shown that the toxicity of water extracts from straw of nine wheat varieties differed in their inhibitory effect on wheat-seedling germination and growth. The alleopathic potential of 20 wheat varieties has also been shown to differentially influence 'Dare' soybean growth (2). Further screening of different weed species and study of the behavior of these toxins in field situations are needed before any possibility of utilizing allelopathy in weed control can be realized. Further studies should include extracts of different wheat varieties and the allelopathic effect on weed and crop species. Such studies would indicate how weed species distribution may shift in the future because of allelopathy under long-term, no-tillage farming practices.

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