

WINTER-ANNUAL WEED MANAGEMENT IN CORN AND SOYBEAN AND THE IMPACT ON SOYBEAN CYST NEMATODE EGG POPULATION DENSITIES

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Summary:

Field research was conducted at Columbia and Novelty, MO to determine the impact of winter-annual weed management systems on corn and soybean grain yields, winter-annual weed control, and soybean cyst nematode (SCN) egg population densities over the crop production cycle. Corn grain yield was not affected by winter-annual weed management systems. Soybean grain yield was not affected in by winter-weed management systems in 2001, but at Columbia in 2002 winter rye and Italian ryegrass reduced soybean grain yield 62 and 64%, respectively. Fall-applied simazine (Princep) + tribenuron (Express) in corn and chlorimuron + sulfentrazone (Canopy XL) in soybean controlled winter-annual weeds greater than 99%. Fall-overseeded winter rye and Italian ryegrass in corn and overseeded Italian ryegrass in soybean controlled winter weeds 66 to 86%. In the soybean studies, race 4 SCN population densities increased ($P=0.08$) in the non-treated control and remained stable ($P=0.55$) with fall-applied chlorimuron + sulfentrazone from fall 2001 to spring 2002 while SCN population densities were reduced ($P=0.06$) with spring-applied chlorimuron + sulfentrazone from fall 2002 to spring 2003. In the corn studies, none of the winter-annual weed management strategies reduced ($P>0.22$) race 2 SCN population densities except winter rye from fall 2001 to spring 2002 ($P=0.05$). This research indicates that control of weed species considered to be weak alternative hosts for SCN affected SCN population densities in some instances when race 4 SCN population densities were high in a continuous soybean production system or race 2 SCN population densities were low in a two-year corn production system.

Introduction:

No-till production systems were implemented to reduce erosion and conserve soil moisture and have increased in the past ten years from 17 to more than 52 million acres (Anonymous 2000). Adoption of no-till production practices has been accompanied by a concomitant increase in the prevalence of winter-annual weeds such as henbit, purple deadnettle (*Lamium purpureum* L.), common chickweed, field pennycress, and others. Weeds can serve as alternative food sources and trap plants for corn and soybean pests. Winter-annual weeds may serve as alternative hosts of soybean cyst nematode (SCN) (Niblack 1999; Venkatesh et al. 2000). Interactions between herbicide treatments and SCN have been previously reported (Levene et al. 1998; Wong et al. 1993; Yang et al. 2002).

Winter rye (Blevins et al. 1971) and perennial ryegrass (*Lolium perenne* L.) (Jung et al. 1991; Sollenberger et al. 1984) have been used as cover crops to reduce soil erosion (Griffith et al. 1986), to improve soil structure and organic matter, for weed suppression (Barnes and Putnam

1986), as winter-annual forage alternatives for tall fescue (*Festuca arundinacea* Schreb.) for stockpile grazing (Bishop-Hurley and Kallenbach 2001), and to reduce nitrate leaching and alter physical and chemical soil characteristics (Mitchell and Teel 1977). However, research evaluating their potential to suppress winter-weed growth or SCN has not been reported. Winter-annual weeds have been more problematic in no-till production systems. Previous research has primarily focused on summer-annual weeds as hosts of SCN, yet no research has evaluated the interaction between winter-annual weed management systems and the impact on SCN population densities. The objective of this research was to determine the impact of winter-annual weed management systems on corn and soybean grain yields, winter-annual weed control, and the subsequent impact on SCN egg population densities from fall to spring in the crop production cycle.

Materials and Methods:

General Methods. Field research was conducted in corn and soybean at the University of Missouri Greenley Research Center at Novelty (40^N 0' 45" N, 92^N 12' 29" W) and Bradford Research and Extension Center at Columbia (38^N 53 ' 44" N, 92^N 12' 39" W) in 2001 and 2002. Herbicide treatments were applied with a CO₂ pressurized backpack sprayer. Winter-annual weed population density was determined in the non-treated control in November each year prior to herbicide application. Winter-annual weeds and cover crops were controlled with a preplant burndown of glyphosate at 0.75 lb ae/a plus diammonium sulfate at 17 lb/100 gallon while summer-annual weeds were controlled with two sequential postemergence applications of glyphosate at 0.75 lb ae/a plus diammonium sulfate at 17 lb/100 gallon or hand removal. Winter rye was 20 to 35 inches tall and Italian ryegrass was 8 to 20 inches tall at the time of application.

Soybean study. The soybean sites had high initial egg population densities since continuous soybeans or double-crop soybeans were grown frequently over the last decade at these sites. SCN in the soybean sites at Novelty and Columbia was HG type 1.2.3.5.6.7 (Race 4) (Niblack et al. 2002). 'DK 38-52' with moderate resistance to SCN races 4 and 13 (W. Parker, personal communication) was planted in 30 inch wide rows at 140,000 seeds/a. Winter-annual weed management treatments included: 1) a non-treated control, 2) spring, preemergence applied chlorimuron at 0.036 lb ai/a + sulfentrazone at 0.2 lb ai/a (formulated as Canopy XL), 3) fall-applied (early-November) chlorimuron at 0.036 lb ai/a + sulfentrazone at 0.2 lb ai/a, 4) overseeded ryegrass at 25 lb/a, and 5) overseeded winter rye at 100 lb/a. Overseeded winter rye and Italian ryegrass were broadcast applied with a hand spinner spreader at the R6 growth stage to simulate seeding with an airplane. All treatments were applied to the same specific plots in both 2001 and 2002 to determine a longer term impact of these treatments SCN egg population densities and avoid possible confounding effects of previous treatments on winter annual weeds and SCN.

Corn study. 'Asgrow RX740 RR' was planted in 76-cm wide rows at 69,000 seeds/ha. The corn sites had low initial egg populations and the SCN at both sites was HG type 1.2.5.7 (Race 2) (Niblack et al. 2002). Winter-annual weed management treatments included: 1) a non-treated control, 2) spring preemergence applied atrazine at 2 lb ai/a, 3) fall-applied (early November) simazine (Princep) at 1 lb ai/a + tribenuron (Express) at 0.016 lb ai/a plus crop oil concentrate at

1% v/v, 4) overseeded Italian ryegrass at 25 lb/a, and 5) overseeded winter rye at 100 lb/a. Winter rye and Italian ryegrass treatments in corn was overseeded prior to the presence of black layer in corn seed and were broadcast applied similar to the soybean study. All treatments were applied to the same specific plots in both 2001 and 2002 to determine a longer-term impact of these treatments on SCN egg population densities and avoid possible confounding effects of previous treatments on winter annual weeds and SCN.

Data Collection and Statistical Analysis. Corn and soybean were harvested with a small-plot harvester and moisture adjusted to 15 and 13% for corn and soybean, respectively. Soil samples for SCN were collected following grain harvest in the fall, 2001 and 2002 at the time of herbicide application. Spring soil samples were collected in the spring the subsequent year. Soil was elutriated (Byrd 1976) and SCN eggs counted to determine differences in SCN population densities in the fall and spring. Winter-annual weeds, winter rye, and Italian ryegrass were harvested from one m² quadrats in each plot, dried, and weighed at spring sampling timing for SCN in 2003. All data were subjected to ANOVA and pooled over locations and years when interactions were not observed. Crop grain yields, winter-annual weed, and winter-annual forage biomass means were separated using Fisher's Protected LSD at $p \leq 0.1$ (SAS, 2005). SCN population densities were analyzed within a treatment with t-tests to compare population densities in the fall and spring. P-values are reported to indicate the magnitude of statistical significance when differences occurred.

Results and Discussion:

Soybean study. The primary winter-annual weeds in the soybean trial were chickweed (8/ft²) and henbit (8/ft²) at Columbia and henbit (14/ft²), chickweed and field pennycress (0.2/ft²) at Novelty in November, 2002. Soybean grain yield was not affected by winter-annual weed management systems at Novelty in 2001 and 2002 or Columbia in 2001 (Table 1). Soybean seeded into Italian ryegrass or winter rye residue at Columbia in 2002 reduced grain yields 29 and 28 bu/acre, respectively, due to poor stand establishment (visual observation). Several researchers have documented that this may be due to allelopathy, competition, poor seed to soil contact, and cool, wet soils (Johnson et al. 1993).

Winter-annual weed biomass was assessed after two years initiation of winter-weed management practices. Fall- and spring-applied chlorimuron + sulfentrazone were more effective in reducing winter-annual weed biomass than winter rye. Spring-applied chlorimuron + sulfentrazone, fall-applied chlorimuron + sulfentrazone, fall-overseeded ryegrass, and fall-overseeded winter rye reduced winter-annual weed total dry weights 51, 99, 66, and 23%, respectively, in the spring, 2003.

Fall-overseeded winter rye and Italian ryegrass produced 19 and 57 g/m², respectively, of forage biomass in the spring 2003. Poor winter rye establishment resulted in lower than anticipated forage biomass production and may reduce its potential usefulness for stockpile grazing during the winter months.

SCN population densities were monitored in the non-treated check and the fall-applied chlorimuron + sulfentrazone treatments during the 2001-2002 season. SCN population density increased in the non-treated check from fall, 2001 to spring, 2002 ($P=0.08$) while there was no change in SCN population density with chlorimuron + sulfentrazone during this period. SCN was monitored in all treatments from fall, 2002 to spring, 2003. Spring-applied chlorimuron + sulfentrazone reduced SCN population density from fall, 2002 to spring 2003 ($P=0.06$); however, none of the other treatments significantly reduced SCN population densities.

Corn study. Common chickweed ($9/\text{ft}^2$) and henbit ($5/\text{ft}^2$) were the primary winter-annual weeds at Columbia and henbit ($5/\text{ft}^2$) was the primary winter-annual weed at Novelty in the corn study in November, 2002. Winter-annual weed management did not affect corn grain yield in 2001 or 2002 when compared to the non-treated control (Table 2). Winter rye, Italian ryegrass, and fall-applied simazine + tribenuron were more effective in reducing spring weed biomass than spring-applied atrazine. Spring-applied atrazine, fall-applied simazine + tribenuron, fall-overseeded ryegrass, and fall-overseeded winter rye reduced total dry weights of winter annuals 39, 100, 86, and 84%, respectively, in the spring, 2003. SCN population densities were low at both corn sites and none of the treatments influenced SCN population density in either year except winter rye from the fall, 2001 to spring, 2002 ($P=0.05$).

Among winter-annual weeds evaluated in our research, henbit and field pennycress have been shown to serve as alternative hosts for race 3 SCN in previous research (Venkatesh et al. 2000). However, in that study, SCN race 3 reproduction was considerably less on henbit and field pennycress than either a SCN susceptible soybean variety or on purple deadnettle. Race 3 SCN has been common in Missouri (Niblack et al., 1993). However, the fields evaluated in this research have may have shifted populations due to extensive use of race 3 resistant soybean cultivars in previous years. This may explain the increase in SCN egg population density from spring to fall, 2002. In addition, there are no published reports to date concerning the host compatibility of specific winter weeds for race 2 or 4 SCN. Our research indicates that if SCN egg population densities are relatively high, such as in continuous soybean, management of weak alternative weed hosts such as henbit and field pennycress with winter-annual weed management systems such as spring-applied chlorimuron + sulfentrazone may show reduction or no increase in SCN egg population density.

Creech et al. (2005) have shown that SCN race 3 reproduction can occur on purple deadnettle following soybean harvest during a mild fall in southwest Indiana. This information combined with the report from Venkatesh et al. (2000) suggests that management of winter-annual weed complexes that contain purple deadnettle as a means of reducing SCN race 3 population density should be considered in the southern cornbelt. However, this research indicates that other races may need attention since use of race 3 resistant cultivars has been utilized throughout the Midwest. Additional research needs to evaluate the impact of grazing winter-annual forages such as winter rye and Italian ryegrass on winter-annual weeds.

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Table 1. Influence of winter-annual weed management systems on soybean grain yield, winter-annual weed and forage biomass, and soybean cyst nematode (SCN) population densities at Novelty and Columbia in 2001 and 2002.

Weed management system	Rate lb ai/acre	Grain yield				Dry weights in spring, 2003				SCN egg population density					
		Novelty		Columbia		Weed	Forage	Fall 2001	Spring 2002	Fall 2002	Spring 2003	P-value ^a	Fall 2002	Spring 2003	P-value
		2001	2002	2001	2002										
Non-treated ^b		47	43	55	45	71	0	9500	12800	0.08	25500	18700	0.22		
Fall-seeded winter rye	100	48	40	56	17	55	19	— ^c	—	—	31600	33400	0.83		
Fall-seeded Italian ryegrass	25	45	40	55	16	24	57	—	—	—	36800	26500	0.34		
Spring-applied chlorimuron + sulfentrazone	0.036 + 0.2	45	42	53	59	35	0	—	—	—	36700	23200	0.06		
Fall-applied chlorimuron + sulfentrazone	0.036 + 0.2	46	43	54	46	1	0	15500	12700	0.55	38200	34700	0.33		
LSD (P=0.1)		NS	NS	NS	14	29	31								

^aP-values indicate the significance between fall and spring SCN population densities.

^bAverage primary winter-annual weeds in November, 2002 at Columbia were common chickweed (8/ft²) and henbit (8/ft²) and at Novelty were henbit (14/ft²), common chickweed, and field pennycress (0.2/ft²).

^cData were not collected.

Table 2. Influence of winter-annual weed management systems on corn grain yield, winter-annual weed and forage biomass, and soybean cyst nematode egg (SCN) population densities at Novelty and Columbia in 2001 and 2002.

Weed management system	Rate lb ai/acre	Grain yield				Dry weight in spring, 2003				SCN egg population densities					
		Novelty		Columbia		Weed	Columbia	Novelty	Columbia	Fall 2001	Spring 2002	Fall 2002	Spring 2003	P-value	
		2001	2002	2001	2002										g/m ²
Non-treated ^b		135	91	51	0	0	0	1530	980	0.36	980	810	0.67		
Fall-seeded winter rye	100	134	86	8	8	58	58	1090	610	0.05	430	1080	0.22		
Fall-seeded Italian ryegrass	25	144	95	7	42	245	245	830	500	0.23	210	350	0.22		
Spring-applied atrazine	2	141	97	31	0	0	0	1250	1110	0.79	640	480	0.61		
Fall-applied simazine + tribenuron	1 + 0.016	131	92	0	0	0	0	890	680	0.61	430	600	0.46		
LSD (P=0.1)		NS	NS	11	15	29									

^aP-values indicate the significance between fall and spring SCN population densities.

^bAverage primary winter-annual weed in November, 2002 at Columbia was chickweed (9/ft²) and henbit (5/ft²) and at Novelty was henbit (5/ft²).