Weed community dynamics in cover crop-based, organic rotational no-till soybean

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Introduction

Cover crops can facilitate reductions in tillage, and recent research has shown that no-till planting of organic soybean into rolled-crimped cereal rye can result in weed suppression and soybean yields that are equivalent to tillage-based management.[1] Soybean population density and cereal rye biomass can interact synergistically to enhance weed suppression and soybean crop yield.[2] Moreover, as in conventional no-till systems, reductions in tillage in organic systems can result in weed community shifts toward perennial species.[3]

In this research, a range of cover crop mulch rates and soybean seeding rates was created to assess their weed suppressive ability and their effect on weed community composition and structure.

Materials and Methods

The study was conducted in 2008 and 2009 in Maryland and Pennsylvania using 5 levels of cereal rye residue representing 0, 0.5, 1, 1.5, and 2 times the ambient level, and 5 soybean seeding rates ranging from 0 to 74 seeds m^{-2}. A cereal rye cover crop was planted in the fall, then clipped and removed from the plots the following spring. Soybeans were seeded at 5 rates, before the clipped rye biomass was returned to the plots. Multivariate analyses were performed using the PC-ORD software package.[4]

Fig. 1: Rye mulch was placed on top of the seeded plots at 5 rates.

Results

■ ***Weed biomass***

- Weed biomass ranged from 0 to 967 g m^{-2} across all site-years.
- The highest levels of weed biomass were observed in MD 2008 (246 g m^{-2}), whereas the lowest levels were observed in PA 2009 (45 g m^{-2}).
- Weed biomass decreased with increasing rye residue and decreased with increasing soybean density.

■ ***NMDS ordination***

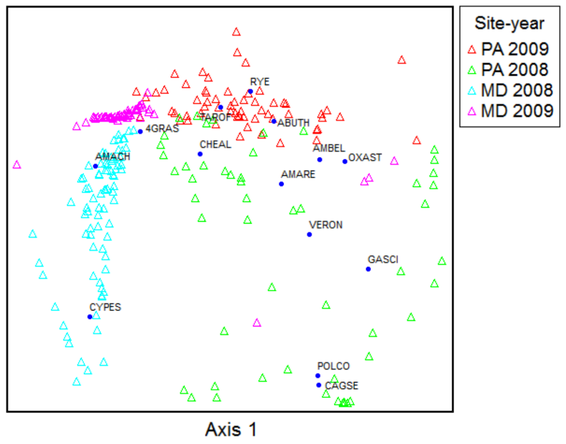

Fig. 2: Nonmetric multidimensional scaling (NMDS) ordination of weed community biomass across the 4 site-years (stress = 15.7, r^2 = 0.36 (axis 1), 0.24 (axis 2), 0.16 (axis 3), cumulative r^2 = 0.76).

■ ***Soybean crop performance***

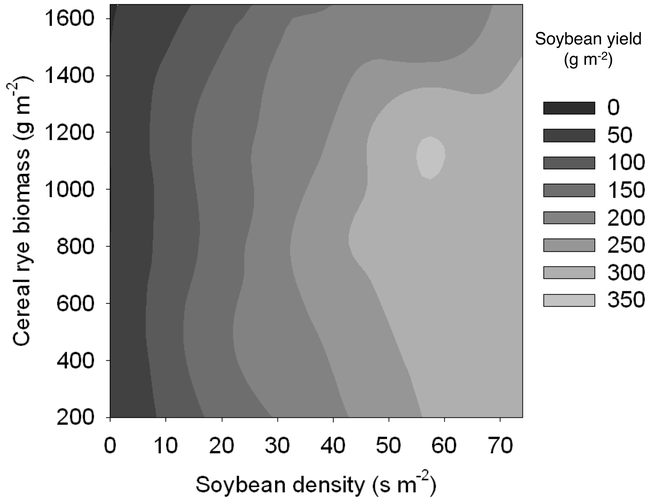

Fig. 3: Contour plot of soybean yield pooled across the 4 site-years.

■ ***Indicator species analysis***

Table 1: Indicator species analysis of weed species in response to cover crop mulch rate and soybean seeding rate.

Factor of interest	Weed species			Indicator species analysis	Regression analysis		
	Bayer code	Latin name	Traits[1]	Treatment associated with weed species[2]	Regression equation with β-coefficients	r^2	*P* value
Cover crop mulch rate (x = the ambient mulch level)	(4GRAS)	4 summer annual grasses[3]	SA, monocot	0x (45.4***)	y = -1.005x + 1.77	0.40	***
	AMACH	*Amaranthus hybridus* L.	A, dicot	0x (19.9***)	y = -0.542x + 0.83	0.17	***
	AMARE	*Amaranthus retroflexus* L.	SA, dicot	0x (17.8***)	y = -0.233x + 0.06	0.10	***
	AMBEL	*Ambrosia artemisiifolia* L.	A, dicot	0x (19.0***)	y = -0.381x + 0.34	0.17	***
	CHEAL	*Chenopodium album* L.	SA, dicot	0x (27.7***)	y = -0.164x – 0.02	0.15	***
	ERICA	*Conyza canadensis* (L.) Cronq.	WA/SA, dicot	0x (3.7*)	y = -0.010x – 0.29	0.01	*
	EROCI	*Erodium cicutarium* (L.) L'He'r. ex Ait.	WA/B, dicot	0x (4.8*)	y = -0.010x – 0.29	0.01	*
	ERYCH	*Erysimum cheiranthoides* L.	A/B, dicot	0x (7.7**)	y = -0.030x – 0.25	0.03	***
	GASCI	*Galinsoga ciliata* (Raf.) Blake	A, dicot	0.5x (7.4*)	y = -0.139x – 0.05	0.07	***
	LAMPU	*Lamium purpureum* L.	WA, dicot	0.5x (3.7*)	----------	<0.01	NS
	MEDLU	*Medicago lupulina* L.	SA/WA/B, dicot	0x (3.3*)	y = -0.015x – 0.28	0.01	*
	MELAL	*Silene alba* (P. Mill.) E.H.L. Krause	SA/WA/B/P, dicot	0x (5.0**)	----------	<0.01	NS
	MOLVE	*Mollugo verticillata* L.	A, dicot	0x (12.0***)	y = -0.014x – 0.28	0.02	**
	OXAST	*Oxalis stricta* L.	P, dicot	0x (9.6**)	----------	<0.01	NS
	PHTAM	*Phytolacca americana* L.	P, dicot	0x (3.5*)	y = -0.003x – 0.30	0.01	*
	PLAMA	*Plantago major* L.	P, dicot	0x (11.3***)	y = -0.043x – 0.24	0.04	***
	POAAN	*Poa annua* L.	P/WA, monocot	0x (4.6*)	y = -0.004x – 0.30	0.02	**
	POLAV	*Polygonum aviculare* L.	SA, dicot	0x (4.1*)	y = -0.019x – 0.27	0.02	**
	(SMART)	Smartweeds (*P. persicaria* and *pensylvanicum*)	A, dicot	0x (15.7*)	y = -0.051x – 0.22	0.05	***
	RORIS	*Rorippa islandica* (Oeder) Borbas	A/B/P, dicot	0x (10.5***)	y = -0.036x – 0.24	0.03	***
	(RYE)	*Secale cereale* L.	A, monocot	0x (19.6***)	y = -0.200x + 0.04	0.10	***
	SOLPT	*Solanum ptychanthum* Dunal	SA/P, dicot	0x (16.2***)	y = -0.029x – 0.26	0.05	***
	TAROF	*Taraxacum officinale* G.H. Weber ex Wiggers	P, dicot	0x (24.8***)	y = -0.104x – 0.12	0.09	***
Soybean seeding rate	(4GRAS)	4 summer annual grasses[3]	SA, monocot	0 seed m^{-2} (18.6*)	y = -0.002x + 1.00	0.02	**
	AMACH	*Amaranthus hybridus* L.	A, dicot	0 seed m^{-2} (14.0*)	y = -0.001x + 0.45	0.02	*
	POLCO	*Polygonum convolvulus* L.	SA, dicot	0 seed m^{-2}(10.5***)	y = -0.001x – 0.13	0.03	***

[1] Annual (A), biennial (B), perennial (P), summer (S), and winter (W).
[2] Indicator value and significance level are presented in parenthesis. Significance level: ***, **, and * indicate significant at $P \leq 0.001$, $P \leq 0.01$, and $P \leq 0.05$, respectively.
[3] Large crabgrass (*Digitaria sanguinalis* (L.) Scop.), barnyard grass (*Echinochola crus-galli* (L.) Beauv.), giant foxtail (*Setaria faberi* Herrm.), and yellow foxtail (*Setaria glauca* (L.) Beauv.) were pooled within each experimental unit.

Conclusions

- Twenty-one weed species were associated with the absence of rye mulch, suggesting that rye suppressed these weed species at mulch rate ≥ 0.5x (Table 1).
- Soybean seeding rate had little impact on weed community composition. Smooth pigweed, wild buckwheat, and 4 summer annual grasses were associated with the absence of soybeans (Table 1).
- The effect of site-year was apparent in the NMDS ordination, indicating that weed community composition varied across site-years (Fig. 2).
- Soybean yields were optimized with 1000-1200 g m^{-2} of rye mulch and soybean seeding rates of about 50-60 seeds m^{-2} in an organic rotational no-till system (Fig. 3).

Fig. 4: Soybeans growing into cereal rye mulch.

Literature Cited

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