Weed and Corn (*Zea mays*) Responses to a Hairy Vetch (*Vicia villosa*) Cover Crop[1]

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Abstract. Field studies were conducted in 1990 and 1991 to determine the effects of corn planting date and hairy vetch control method on the efficacy of fall-planted hairy vetch as a weed-suppressive cover crop for no-till corn. Glyphosate controlled hairy vetch when applied at the early bud growth stage (April), but hairy vetch residue provided no weed control compared to the weedy check. Mowing was not an effective means of suppressing hairy vetch at the early bud stage. Untreated hairy vetch reduced weed biomass 96% in 1990 and 58% in 1991 but reduced yield over 76% in April-planted corn. There was no competition of untreated hairy vetch with corn when corn planting was delayed until May or June (mid- or late-bloom growth stages of hairy vetch). Corn planted in May into untreated hairy vetch yielded similarly to corn planted in a no-cover weed-free check. **Nomenclature:** Glyphosate, N-(phosphonomethyl)glycine; corn, *Zea mays* (L.) 'OF9 X LH82'; common lambsquarters, *Chenopodium album* L. #[3] CHEAL, hairy vetch, *Vicia villosa* (Roth) # VICVI.

Additional index words: Cultural weed control, mulch, alternative agriculture, reduced herbicide.

INTRODUCTION

Hairy vetch is a winter annual legume historically used in the northcentral United States as a winter cover crop (11, 12) and recently investigated for its potential to suppress weeds in no-till corn (5, 9, 15). Biomass production by fall-planted hairy vetch ranged from 2140 to 9010 kg ha^{-1} the following spring, indicating potential for this legume to suppress weeds through competition during its spring growth and then through mulching after senescence (8, 10). Hairy vetch residue may also suppress weed germination through allelopathy (2, 17).

Conflicting results of the effectiveness of winter annual legume cover crops for weed control have been reported. Subterranean clover (*Trifolium subterraneum* L.) provided equal or better weed control in no-till corn than conventional herbicide treatments (6). Hairy vetch residue was negatively correlated with total weed density but not with weed biomass in no-till corn (15). Residue from flail-chopped hairy vetch reduced weed dry weight during the first six weeks after corn planting compared with a weedy check, but weed dry weight in hairy vetch at the end of the season was equal to that of the weedy check (9). Weed suppression by hairy vetch increased when corn planting and hairy vetch mowing were simultaneously delayed from mid-May until early June (9).

Cover crop management for weed control requires a balance between cover crop biomass production for effective weed suppression and control of the cover crop to prevent competition with grain crop seedlings and subsequent yield losses. Unsuppressed hairy vetch controlled weeds effectively in no-till corn in Nebraska, but reduced corn grain yield (5). When hairy vetch was killed with 2,4-D [(2,4-dichlorophenoxy)acetic acid], the hairy vetch residue rapidly degraded and did not control weeds adequately (5). Where eleven herbicides were applied to cover crops before cotton (*Gossypium hirsutum* L.) planting, hairy vetch was adequately controlled in only one out of three years when treated at an advanced growth stage, cotton stands were reduced, and additional herbicide was required for acceptable weed control (32).

The objective of this research was to determine the effects of corn planting date and hairy vetch control method on weed growth, hairy vetch growth, and corn yield in no-till corn established in fall-seeded hairy vetch.

MATERIALS AND METHODS

Experimental design. Field experiments were conducted in 1990 and 1991 on a Crosby silt loam soil

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[3]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 W. Clark St., Champaign, IL 61820.

(fine, mixed, mesic Aeric Ochraqualfs) at two different sites at The Ohio State University Agronomy Farm in Columbus, OH. Both sites had been previously cropped in wheat. Seed of hairy vetch (hereafter referred to as vetch) were inoculated and drilled at 45 kg ha^{-1} on 28 Aug., 1989 and 1990 into a seedbed prepared with a tandem disk.

Treatments were replicated four times in a randomized complete block design and arranged in a split plot with corn planting dates as main plots and cover crop treatments as subplots. Corn planting dates were 27 Apr., 1990 and 30 Apr., 1991, 24 May, 1990 and 16 May, 1991, and 18 June, 1990 and 5 June, 1991, when vetch was at early bud, mid-bloom, and late-bloom growth stages, respectively.

Cover crop treatments included vetch control method, a weedy check, and a weed-free check. The weedy and weed-free checks were first established by fall and spring applications of paraquat (1,1′-dimethyl-4,4′-bipyridinium ion) or glyphosate to kill vetch prior to corn planting. Residual vetch remaining at corn planting was removed by hand and glyphosate was applied at 2.8 kg ai ha^{-1} to control all weeds. The weed-free checks were hand weeded throughout the season whereas the weedy checks received no further weed control.

Vetch control methods included no treatment (untreated), rolling, chopping, mowing, and glyphosate application. Chopping was introduced in 1991 as a variation of the rolling treatment. All treatments were applied immediately before or after corn planting. The vetch was rolled with a hand-drawn 60-cm diam, 270-kg water-filled turf roller and chopped with a tractor-drawn 120-cm diam, 410-kg water-filled drum roller modified by horizontal attachment of ten 9-cm steel blades. Mowing was done with a flail-chop forage harvester for the early and middle planting dates in 1990, and with a rotary mower for the late planting date in 1990 and for all planting dates in 1991. Glyphosate was applied at 2.8 kg ai ha^{-1} with 0.5% v/v nonionic surfactant in a carrier volume of 280 L ha^{-1}. Percentage vetch control was visually evaluated one week before natural vetch senescence on a scale of 0 (no vetch killed) to 100 (all vetch killed).

To distinguish the effects on corn yield of vetch alone from vetch plus weeds, the vetch subplots were divided into two 3- by 12-m sub-subplots for two POST weed control treatments. One sub-subplot received no further treatment and the other was hand-weeded at 7 wk after corn planting (WAP)[4].

OF9 X LH82 corn was no-till seeded in 76-cm wide rows to achieve a corn population of 66 700 plants per ha at 4 WAP. A four-row no-till corn planter fitted with 24-cm diam furrowing disks and 35-cm diam double disk openers[5] was used. Urea was broadcast at 112 kg N ha^{-1} at corn planting and an additional 56 kg N ha^{-1} as NH_4NO_3 were applied at 7 WAP.

Spring vetch shoot growth from April through mid-June was determined by harvesting shoot biomass every 7 or 14 d from randomly selected plots within each replication in which no corn had been planted. Shoots were harvested from 0.25-m^2 quadrats in 1990 and from 0.75 m^2 in 1991. Quadrat size was enlarged in 1991 to reduce variability among samples. To determine vetch shoot biomass remaining after corn planting and weed shoot biomass, a 0.75-m^2 area was harvested from subplots at 7 WAP and from sub-subplots at 15 WAP in both years. Weeds were separated by species and counted. All vetch and weed samples were oven-dried at 40 C and dry weights were recorded. Corn ears were hand-harvested from a 3-m length of the two center rows in each sub-subplot and shelled. Grain weights were adjusted to 15.5% moisture and expressed as grain yield in kg ha^{-1}.

Data analysis. Data for 1990 and 1991 were analyzed separately due to significant treatment by year interactions for corn yield, weed density, and weed biomass. Analysis of variance was used to determine significant main effects and interactions. Visual percentage estimates of vetch control were subjected to arcsin transformation and weed densities and weed biomass of individual weed species were subjected to square root transformation before analysis to normalize residuals (13). Means were separated by Fisher's Protected LSD Test at the 5% level of significance.

RESULTS AND DISCUSSION

Hairy vetch response. Vetch shoot biomass increased rapidly during April in 1990 and through early May in 1991, then approached a constant level during flowering in May and June each year (Figure 1). Biomass of vetch at the early bud stage was greater in 1990 (6030

[4]Abbreviations: WAP, weeks after planting.

[5]Case International Model 900 Cyclo Air Trailing Planter. J. I. Case Co., 2525 West Hampton Ave., Milwaukee, WI 53209.

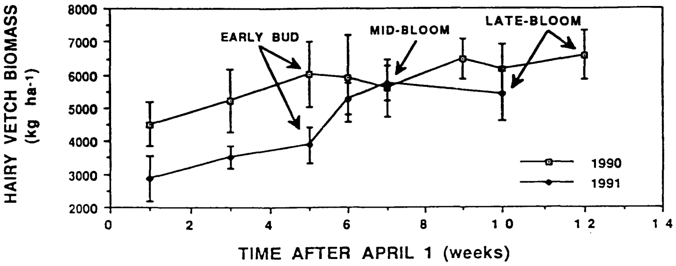

Figure 1. Shoot biomass accumulation of fall-seeded hairy vetch in 1990 and 1991 prior to corn planting and control. Data points shown are the means of four replications ± 1 standard deviation.

kg ha^{-1}) than in 1991 (3880 kg ha^{-1}), but was similar between years at mid- and late-bloom growth stages, ranging from 5440 to 6610 kg ha^{-1}. Senescence of vetch began July 7, 1990 and June 17, 1991, about 5 and 2 wk after the late planting dates, respectively.

Vetch was more easily controlled in 1991 than in 1990 (Table 1). In 1990 all treatments and in 1991 all treatments except glyphosate gave increased control of vetch as corn planting date was delayed. Percent control averaged over vetch treatments in 1990 was 20, 75, and 99% when vetch was treated at the early bud, mid-bloom, and late-bloom growth stages, respectively, and in 1991 was 69, 92, and 99% for the same dates. Glyphosate controlled vetch more effectively than all other treatments when applied at the early bud stage in both years, providing complete vetch control in 1991. Mowing was ineffective in controlling vetch in the early bud stage in 1990 and gave 74% control of vetch in the same growth stage in 1991. Vetch control by glyphosate or mowing applied at the mid- and late-bloom stages was comparable in both years and exceeded 90%. Untreated vetch at mid- or late-bloom was partially or completely controlled by the mechanical action of the no-till corn planter. In most cases, rolling or chopping did not improve vetch control over that provided by the no-till planter.

Vetch shoot biomass at 7 WAP was greater in 1990 than in 1991 (Table 2), averaging 5320 kg ha^{-1} in 1990 over corn planting dates and vetch treatments compared to 3410 kg ha^{-1} in 1991. Vetch shoot biomass at 7 WAP of untreated or rolled vetch for the early corn planting date was similar to or greater than biomass present at planting (6030 and 3880 kg ha^{-1} in 1990 and 1991, respectively), which was consistent with the lack of control of vetch by these treatments (Tables 1 and 2). Mowing and glyphosate reduced vetch shoot biomass approximately 35 and 60%, respectively, compared to untreated vetch in both years (Table 2). There were smaller or no differences in shoot biomass among treatments for vetch treated at the later two planting dates (Table 2) since vetch had already attained its maximum shoot biomass at the time of treatment (Figure 1). The only significant planting date differences within a treatment (Table 2) occurred where vetch was controlled at the early planting date (glyphosate) or where there was little or no control at that planting date (untreated or rolled). Similar, but smaller treatment and planting date effects were observed at 15 WAP (data not shown).

The earlier senescence, greater ease of control, and low biomass of vetch in 1991 compared to 1990 may have been due to drought in 1991. Monthly rainfall was similar from January through April in both years, but in May, June, and July 1990, monthly rainfall was 17.8, 13.0, and 20.0 cm compared to only 6.3, 7.1, and 3.0 cm, respectively, in 1991.

Weed response. Differences in weed density and biomass at 7 and 15 WAP were similar among treatments, so only the data for 15 WAP are presented. Common lambsquarters dominated both experimental

Table 1. Hairy vetch control as affected by treatment at the early bud (Early), mid-bloom (Mid), and late-bloom (Late) growth stages. Percent control was estimated visually on July 1, 1990 and June 10, 1991[a,b].

Vetch treatment	1990 Early	1990 Mid	1990 Late	1991 Early	1991 Mid	1991 Late
	% control					
Untreated	0 a A	51 a B	97 a C	62 ab A	82 a B	95 a C
Rolled	0 a A	56 a B	97 a C	63 ab A	87 ab B	99 ab C
Chopped	—	—	—	47 a A	95 bc B	99 ab B
Mowed	19 b A	93 b B	100 b C	74 b A	100 c B	100 b B
Glyphosate	61 c A	100 c B	100 b B	100 c A	97 c A	100 b A

[a]Means within columns followed by the same lower case letter are not statistically different according to the LSD (0.05) test.

[b]Means within rows and within a year followed by the same upper case letter are not statistically different according to the LSD (0.05) test.

Table 2. Hairy vetch shoot biomass at 7 WAP as affected by treatment at vetch early bud (Early), mid-bloom (Mid), and late-bloom (Late) growth stages[a,b].

Vetch treatment	1990 Early	1990 Mid	1990 Late	1991 Early	1991 Mid	1991 Late
	kg ha^{-1}					
Untreated	8560 a A	6030 a B	4620 a B	4510 a A	4100 a A	3420 a A
Rolled	8130 a A	4830 ab B	4960 a B	4320 a A	3180 ab A	3640 a A
Chopped	—	—	—	3750 ab A	3360 ab A	3290 a A
Mowed	5430 b A	3510 bc B	6470 a A	2940 b A	2250 c A	3130 a A
Glyphosate	3410 c A	3180 c A	4680 a A	1960 c A	3620 ab B	3720 a B

[a]Means within columns followed by the same lower case letter are not statistically different according to the LSD (0.05) test.
[b]Means within rows and within a year followed by the same upper case letter are not statistically different according to the LSD (0.05) test.

sites and composed 52% of total weed biomass in the weedy check, averaged over corn planting dates and years.

Significant treatment by planting date interactions occurred for common lambsquarters and total weed density and biomass in one or both years (Tables 3 and 4). The interaction showed that untreated vetch reduced weed emergence and biomass compared to the weedy check for the early planting date, but for the late planting date there were no differences between vetch treatments and the weedy check. Weed emergence in the weedy check declined with a delay in corn planting (Table 3), contributing to the lack of treatment differences at the later dates.

For the early corn planting date, untreated vetch suppressed common lambsquarters emergence and biomass 100% in 1990 and 84 and 87%, respectively, in 1991 (Tables 3 and 4). Similarly, untreated vetch reduced total weed density and biomass 88 and 96%, respectively, in 1990, and 55 and 58%, respectively, in 1991 (Tables 3 and 4); however, corn growth and yield were also severely suppressed (described later). Chopped vetch suppressed total weed density and biomass 65% in 1991, while mowed or glyphosate-treated vetch gave little or no suppression of total weed density or biomass compared to the weedy check in either year. Weed densities and biomass in rolled vetch plots were similar to untreated vetch plots, and weed populations were low in both treatments across all corn planting dates.

There were significant negative correlations between vetch biomass at 7 WAP and weed density for all

Table 3. Influence of hairy vetch treatment and corn planting date on common lambsquarters (CHEAL) and total weed (Total) density at 15 WAP. Corn was planted at vetch early bud (Early), mid-bloom (Mid), and late-bloom (Late) growth stages. Vetch treatments were compared with a no-cover weedy check[a,b].

Weed	Vetch treatment	1990 Early	1990 Mid	1990 Late	1990 Mean	1991 Early	1991 Mid	1991 Late	1991 Mean
		no m^{-2}							
CHEAL	Untreated	0 a A	0 a A	0 a A	0 a	3 a A	5 a A	2 a A	3 a
	Rolled	0 a A	1 a A	0 a A	0 a	2 a A	13 a B	1 a A	5 a
	Chopped	—	—	—	—	9 ab A	6 a B	5 a B	7 a
	Mowed	0 a A	1 a A	0 a A	1 ab	17 b A	2 a B	3 a B	7 a
	Glyphosate	1 b A	0 a B	0 a B	1 b	23 b A	3 a B	2 a B	9 a
	Weedy check[d]	5 c A	5 b A	2 b B	4 c	19 b A	7 a B	0 a C	9 a
Total	Untreated	5 ns[c]	10	4	7 a	22 a A	11 a A	8 a A	14 a
	Rolled	8	16	5	10 ab	17 a AB	27 ab B	6 a A	17 a
	Chopped	—	—	—	—	17 a A	25 ab A	12 a A	18 a
	Mowed	25	23	7	18 c	33 ab A	18 ab AB	10 a B	20 a
	Glyphosate	20	19	6	15 bc	46 b A	19 ab B	4 a C	23 a
	Weedy check[d]	41	34	20	32 d	49 b A	34 b A	2 a B	28 a

[a]Means within columns followed by the same lower case letter are not statistically different according to the LSD (0.05) test.
[b]Means within rows and within a year followed by the same upper case letter are not statistically different according to the LSD (0.05) test.
[c]The treatment by planting date interaction was not significant, therefore individual treatment by planting date means were not compared by LSD.
[d]These checks had no vetch or weeds at planting. Weeds were not controlled after planting.

Table 4. Influence of hairy vetch treatment and corn planting date on common lambsquarters (CHEAL) and total weed (Total) biomass at 15 WAP. Corn was planted at vetch early bud (Early), mid-bloom (Mid), and late-bloom (Late) growth stages. Vetch treatments were compared with a no-cover weedy check[a,b].

Weed	Vetch treatment	1990 Early	1990 Mid	1990 Late	1990 Mean	1991 Early	1991 Mid	1991 Late	1991 Mean
		g m^{-2}							
CHEAL	Untreated	0 ns[c]	0	0	0 a	60 a A	14 a A	8 a A	28 a
	Rolled	0	0	0	0 a	58 ab A	48 abc A	5 a A	37 ab
	Chopped	—	—	—	—	133 bc A	62 c A	59 b A	85 bc
	Mowed	70	2	0	24 ab	178 c A	12 ab A	24 ab A	71 bc
	Glyphosate	33	0	0	11 a	502 d A	12 a B	24 ab B	180 c
	Weedy check[d]	106	41	3	50 b	452 d A	41 bc B	8 a B	167 c
Total	Untreated	9 a A	26 a A	5 a A	14 a	274 b A	57 a B	69 ab B	134 ab
	Rolled	17 a A	43 ab A	28 a A	30 a	80 a A	90 ab A	39 ab A	69 a
	Chopped	—	—	—	—	231 b A	165 b A	147 b A	181 bc
	Mowed	147 b A	128 c A	6 a B	93 b	377 b A	79 ab B	71 ab B	176 bc
	Glyphosate	150 b A	39 ab B	21 a B	70 b	663 c A	137 ab B	35 a B	278 c
	Weedy check[d]	217 b A	103 bc B	30 a C	117 b	647 c A	152 ab B	12 a C	270 c

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[b]Means within rows and within a year followed by the same upper case letter are not statistically different according to the LSD (0.05) test.

[c]The treatment by planting date interaction was not significant, therefore individual treatment by planting date means were not compared by LSD.

[d]These checks had no vetch or weeds at planting. Weeds were not controlled after planting.

planting dates in 1990 (r = −0.70 to −0.87) and for the early planting date in 1991 (r = −0.58), as well as between vetch biomass and weed biomass (data not shown). The suppression of weeds by vetch occurred primarily through suppression of weed emergence since weed biomass was reduced in proportion to reductions in density. Teasdale et al. (15) also reported a negative correlation of vetch and rye (*Secale cereale* L.) biomass with weed density, but found no correlation with weed biomass.

Weaker negative correlations of vetch biomass with weed density occurred at middle and late (r = −0.70) versus the early (r = −0.87) corn planting date in 1990 and overall in 1991 compared to 1990. This may have been due to the absence of uncontrolled, living vetch after corn planting in those plots. Shade produced by a living canopy is enriched in far-red light, which inhibits germination of common lambsquarters and other species (1, 7, 14). The data presented here suggest that live vetch is more effective in suppressing weed emergence than dead vetch residue. Emergence and growth of common lambsquarters was suppressed by vetch in both years, perhaps because this species germinates readily at cool temperatures (4, 16, 18), coincident with timing of active growth of vetch.

Corn yield. Corn yield data were divided into two sets for statistical analysis to distinguish the effects on corn yield of vetch alone from those of weeds growing through the vetch. One set included only the data from weed-free vetch sub-subplots, whereas the other set included only data of weedy vetch sub-subplots (Table 5).

Corn yields were abnormally low in 1991 due to drought (Table 5) and further reduced at the early corn planting date due to poor emergence as a result of wet soil conditions at planting and incomplete furrow closure. Corn yield losses occurred in all weedy vetch plots for the early corn planting date (Table 5). These losses were due primarily to competition with uncontrolled vetch in untreated, rolled, mowed, or chopped vetch plots, whereas yield losses in vetch plots treated with glyphosate were due to competition with weeds that emerged through the vetch. These results were consistent with percent vetch control (Table 1) and weed growth (Table 3) in the various vetch treatments.

Corn planted into vetch at mid-bloom yielded similarly to the weed-free check except for the mowed vetch treatment in 1990, in which competition from weeds growing through the vetch reduced corn yield (Table 5). Yield of corn planted into vetch at late-bloom was equal to corn yield in the weed-free check at that planting date for most vetch treatments. Yield of corn planted into vetch tended to be highest for the middle planting date. Competition with uncontrolled vetch caused yield losses at the early planting date and the shorter growing season caused yield losses at the late planting date.

These data indicate that when corn was planted at the vetch early bud stage, vetch was most effective in

Table 5. Grain yield of corn planted into a hairy vetch cover crop at vetch early bud (Early), mid-bloom (Mid), and late-bloom (Late) growth stages. Vetch treatments were compared to a no-cover weed-free check (Weed-free check). Weeds in vetch plots were removed by hand at 7 WAP (yes) or not removed (no)[a,b].

Vetch treatment	Weed removal	1990 Early	1990 Mid	1990 Late	1991 Early	1991 Mid	1991 Late
		kg ha^{-1}					
Untreated	no	130* A	7350 B	6520 B	670* A	4410 B	1170* A
Untreated	yes	190* A	8520 C	5380 B	600* A	4380 B	1490* A
Rolled	no	40* A	7630 B	7510* B	920* A	3200 B	2410 B
Rolled	yes	430* A	8320 B	7850* B	1470* A	3810 B	2780 B
Chopped	no	—	—	—	500* A	3660 B	2340 B
Chopped	yes	—	—	—	1020* A	4400 C	2610 B
Mowed	no	3000* A	6830* B	5900 B	580* A	3090 B	1670* A
Mowed	yes	5220* A	8190 B	6150 A	1680* A	4670 B	1950* A
Glyphosate	no	8020* A	7700 A	5630 B	720* A	3910 B	2830 B
Glyphosate	yes	9060 A	8100 AB	6680 B	2960 A	4350 B	2720 A
Weed-free check	yes[c]	9770 A	8560 A	5310 B	2840 A	4130 B	3300 AB

[a]Vetch treatment means within columns followed by an asterisk (*) are statistically different from the weed-free check according to the LSD (0.05) test.

[b]Means within rows and within a year followed by the same letter are not statistically different according to the LSD (0.05) test.

[c]These checks had no vetch or weeds at planting. Plots were maintained free of weeds throughout the growing season.

controlling weeds when it was left untreated, but also severely reduced corn yield. Glyphosate was the only treatment that provided sufficient control of vetch to avert corn yield losses caused by vetch. However, vetch residue in this treatment provided no subsequent weed suppression and corn yield was reduced 18% in 1990 and 75% in 1991 compared to the weed-free check.

On the other hand, vetch did not compete with corn when corn was planted at the vetch mid-bloom stage, and no treatment was needed for its control at corn planting. The vetch mid-bloom planting date allowed maximum vetch shoot development and weed suppression. From the standpoint of weed control, these data suggest that vetch may be of greater benefit for corn planting dates timed to coincide with vetch mid-bloom (May) versus early bud (April) growth stages. However, delayed corn planting results in reduced corn yield potential, and the economic trade-off between reduced herbicide inputs versus reduced corn yield warrants further evaluation.

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