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# Weed Suppression by Live and Desiccated Hairy Vetch (*Vicia villosa*)[1]

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*Abstract.* **Hairy vetch was grown as a winter annual cover crop and evaluated for weed suppression when desiccated by paraquat or left alive until natural senescence in a 3-yr field experiment. Total weed density and biomass were variable in the desiccated hairy vetch treatment relative to a bare soil treatment but were consistently lower in the live hairy vetch treatment relative to the desiccated or bare soil treatments. An average of 87% of sites under live hairy vetch compared to 8% of sites under desiccated hairy vetch transmitted less than 1% of unobstructed sunlight. The red (660 nm) to far-red (730 nm) ratio of transmitted light was reduced by 70% under live hairy vetch compared to 17% under desiccated hairy vetch. Daily maximum soil temperature and diurnal soil temperature amplitude were reduced by live hairy vetch > desiccated hairy vetch > bare soil. Soil moisture content was greater under both live and desiccated hairy vetch compared to bare soil during droughty periods. Changes in light extinction, red to far-red ratio, and diurnal soil temperature amplitude were sufficient to explain greater weed suppression by live than desiccated hairy vetch. Nomenclature: Paraquat, 1,1′-dimethyl-4,4′-bipyridinium ion; hairy vetch, *Vicia villosa* Roth.**
*Additional index words:* **Light transmittance, light spectrum, soil temperature, soil moisture.**

## INTRODUCTION

Hairy vetch is a winter annual legume suitable for use as a cover crop in most areas of the United States. It is planted in the fall and produces substantial vegetative biomass with a high nitrogen content by the time of planting in spring (5, 15). Hairy vetch has been a particularly successful cover crop for grain crops such as corn because release of nitrogen can supply much of the nitrogen requirement (2, 7, 16).

Hairy vetch residue on the surface of soil with no tillage suppressed weed emergence but the degree of suppression depended on the quantity of residue biomass (13). Residue altered the light, temperature, and moisture conditions under the mulch sufficiently to suppress emergence of many weeds but not enough to prevent emergence completely (14). Light extinction by residue was an important factor influencing suppression of many annual weeds (12, 13). Hairy vetch has been shown to contain allelopathic compounds (18) but allelopathy appears to be relatively unimportant when residue is on the soil surface (12).

Hairy vetch is desiccated with a contact herbicide prior to planting a summer crop under recommended no-tillage practices (17). However, if left alive, hairy vetch will continue growing until natural senescence occurs in late June under Maryland conditions. Preliminary observations indicated that living hairy vetch suppressed weeds more than desiccated hairy vetch residue. Filtration of red light by the leaf canopy of live vegetation is known to reduce the red to far-red ratio of transmitted light causing an inactivation of phytochrome and inhibition of seed germination (4, 11). However, there is little information on differences in environmental conditions under live versus killed cover crop residue and whether these differences could account for differences in weed suppression.

Research was conducted to determine the difference in weed suppression by desiccated hairy vetch residue compared to live hairy vetch and the relative changes in light, temperature, and moisture conditions under desiccated and live hairy vetch that may account for differential weed suppression.

## MATERIALS AND METHODS

This experiment was conducted during 1989 to 1991 at the South Farm of the Beltsville Agricultural Research Center, Beltsville, MD, on a Keyport silt loam soil (Aquic Hapludults; clayey, mixed, mesic). The field was prepared by plowing, disking, and cultimulching before planting hairy vetch in late September or early October. Before initiation of the experiment, areas of the field designated to contain bare soil plots were kept free of vegetation with glyphosate [*N*-(phosphonomethyl)glycine] applications as needed.

The experimental area was desiccated with 1.12 kg $ha^{-1}$ of paraquat May 19, May 8, and May 8 of 1989, 1990, and 1991, respectively, except for designated areas where hairy vetch remained alive. Plants desiccated included hairy vetch, a few winter annuals growing with the hairy vetch, and a few emerged summer annual weeds in the vegetation-free areas. After desiccation, plots measuring 1 by 1 m were flagged for weed density and biomass determinations later in the season. Three treatments consisting of no cover crop, desiccated hairy vetch, and live hairy vetch were established with four replications of each treatment arranged in a randomized complete block design. Each plot was surrounded by a similarly treated area to support biomass sampling and environmental measurements.

Hairy vetch biomass was determined from 1-$m^2$ samples taken 2 to 4 d after desiccation and, in 1990 and 1991, at approximately monthly intervals until weed biomass sampling. Weed density by species was determined in three (1989 and 1990) or five (1991) 0.1-$m^2$ frames per plot at 4 and 8 wk after desiccation. Nine weeks after desiccation in 1989,

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weed biomass was harvested from the entire area of each 1-$m^2$ plot. Twelve weeks after desiccation in 1990 and 1991, weed density and biomass by species were determined from the entire area of each plot. Analysis of variance was used for determinations of statistical significance. Weed density data were square root transformed prior to analysis to correct for heterogeneity of variance.

Photosynthetic photon flux density (PPFD) transmittance through hairy vetch was determined within 1 h of solar noon during clear sky conditions at 2 to 3 wk after desiccation. Simultaneous measurements were made with two point quantum sensors[3], one positioned under and the other over hairy vetch. Transmittance was determined as the ratio of these readings after adjustment for the measured difference in unobstructed sunlight readings by both sensors. Measurements were made at twelve sites per plot on a predetermined grid beneath hairy vetch. Hairy vetch vegetation was lifted gently with a ruler to move the sensor between measurements.

The spectrum of radiation transmitted through hairy vetch from 400 to 1100 nm was determined by a spectroradiometer[4] with a remote cosine receptor on the end of a fiber optic probe within 1 h of solar noon under clear sky June 18, 1990 and May 22, 1991. Measurements were made at 12 sites under desiccated hairy vetch and 3 sites under live hairy vetch in 1990 and at 16 sites under both desiccated and live hairy vetch in 1991. Spectral transmittance was the ratio of measurements made under hairy vetch divided by unobstructed measurements made above hairy vetch.

Soil temperature was measured to a 5-cm depth with permanently installed maximum-minimum dial thermometers. Four, two, and four instruments were installed per treatment in 1989, 1990, and 1991, respectively. Readings were made on 7, 22, and 14 d during the first 4 wk after desiccation in 1989, 1990, and 1991, respectively. Readings made during this 4-wk period by each instrument were averaged and these average readings were used for analysis of variance.

Soil moisture content in the surface 2.5 cm was determined gravimetrically June 2, 1989 and May 23, 1991. Three soil samples were taken from each plot and composited in a sealed plastic bag for transportation to the dryer. Soil was dried at 120 C. Soil moisture content is expressed as percent weight of moisture lost during drying relative to soil dry weight.

## RESULTS AND DISCUSSION

Hairy vetch established a uniform stand and produced a complete groundcover in each experiment. Hairy vetch biomass at the time of desiccation was 462, 319, and 375 g $m^{-2}$ in 1989, 1990, and 1991, respectively. These are within the range of values reported by others (2, 7). After desiccation by paraquat in May, hairy vetch residue decomposed relatively rapidly leaving approximately 20% of the original biomass by August (Figure 1). If left untreated,

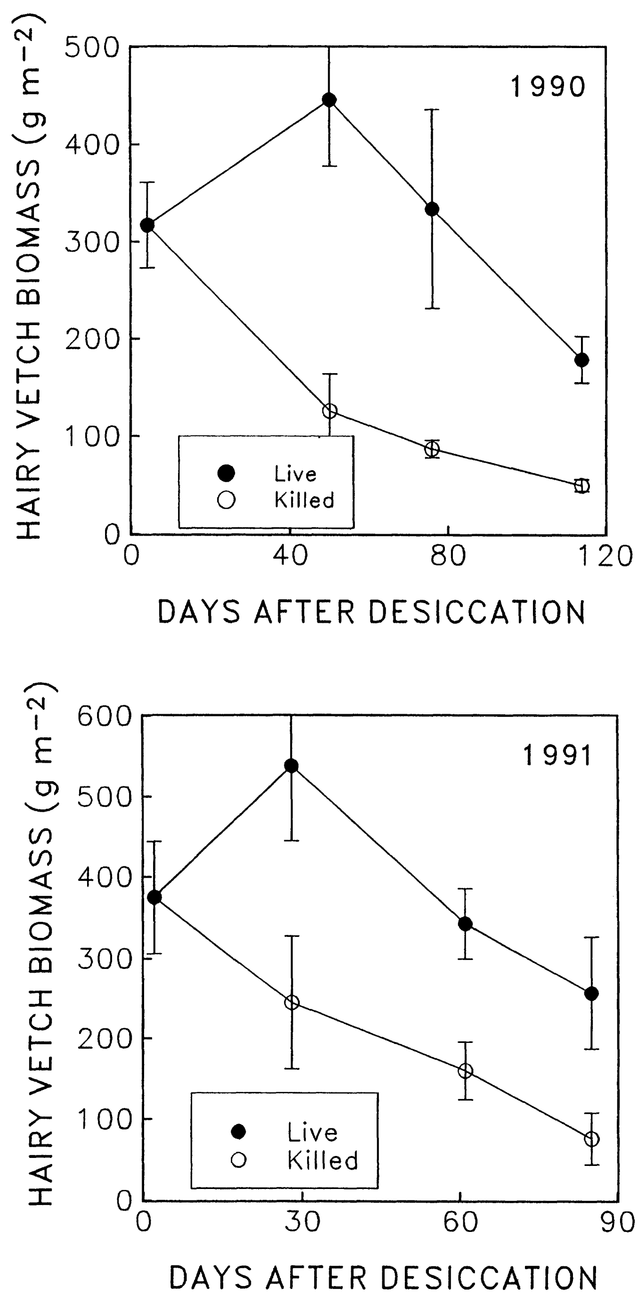


*Figure 1.* Changes in hairy vetch biomass (dry weight) throughout the 1990 and 1991 experiments. Hairy vetch was either desiccated with paraquat on May 8 of each year or remained alive until natural senescence approximately 6 wk after desiccation. Vertical bars on each value is the standard deviation.

[3]Model LI-190. LI-COR, Lincoln, NE.
[4]Model LI-1800. LI-COR, Lincoln, NE.
[5]Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

hairy vetch continued to grow approximately 150 g $m^{-2}$ of additional biomass before senescing in late June (Figure 1). After senescence, decomposition of residue from the live treatment progressed at a similar rate to that of the desiccated residue. The live treatment maintained a higher biomass than the desiccated treatment at all sampling dates after the initial paraquat treatment.

The live hairy vetch treatment consistently reduced weed density during the first 8 wk of the experiment relative to the desiccated hairy vetch and bare soil treatments (Table 1). This resulted in a reduction of weed biomass every year of the experiment. The influence of desiccated hairy vetch residue was variable. The residue either reduced or had no influence on weed density and biomass relative to the bare soil treatment in 1989 or 1990 when soil moisture was adequate. However, the residue increased weed biomass relative to the no-cover crop treatment in 1991 when an extended hot, dry period persisted for the first 6 wk after desiccation.

The major weed species in this field were barnyardgrass [*Echinochloa crus-galli* (L.) Beauv. #[5] ECHCG], giant green foxtail [*Setaria viridis* var. *major* (Gaudin) Pospichel # SETVM], yellow foxtail [*Setaria glauca* (L.) Beauv. # SETLU], and yellow nutsedge (*Cyperus esculentus* L. # CYPES). There was considerable variability in distribution of these species throughout the field making if difficult to demonstrate statistically significant changes in community composition with any treatment. Table 2 shows that biomass was distributed amongst the four major species in 1990 and that giant green foxtail dominated all treatments in 1991. There were few significant differences between treatments; however, there was a trend for giant green foxtail biomass to be greater in the desiccated hairy vetch than in the other treatments and for yellow foxtail and yellow nutsedge biomass to be greater in the bare soil than in the other treatments.

Mean light penetration of desiccated hairy vetch residue was 11, 24, and 16% of unobstructed sunlight in 1989, 1990, and 1991, respectively. Mean light penetration of live hairy vetch was 0.31, 0.85, and 0.65% in 1989, 1990, and 1991, respectively. However, mean light penetration may not be as meaningful for understanding the light environment under hairy vetch as the frequency distribution of light penetration at specific sites (Table 3). Relatively few sites under desiccated hairy vetch transmitted less than 1% PPFD and a substantial number of sites transmitted greater than 10% PPFD (represents a level that might be found on a cloudy day). In contrast, the majority of sites under live hairy vetch transmitted less than 1% PPFD and very few sites transmitted greater than 10% PPFD.

Light levels of less than 0.1% transmittance are required to activate phytochrome-mediated germination and even lower levels are required for the very low fluence rate response (6). All sites under desiccated hairy vetch and the majority of sites under live hairy vetch permitted sufficient light transmittance to activate phytochrome-mediated germination of weed seeds at or near the soil surface. However, the majority of sites under live hairy vetch transmitted light below 1% which represents the light compensation point of most weed species (8), whereas the majority of sites under desiccated hairy vetch were not below the light compensation point. Therefore, live hairy vetch probably would suppress weeds that were not able to penetrate hairy vetch before exhausting energy reserves, whereas desiccated hairy vetch probably would permit emergence of the majority of germinated weeds. Previous research showed that desiccated residue quantities of two to four times the natural biomass did not reduce light penetration as much as live hairy vetch (14).

The spectrum of light transmitted through hairy vetch was influenced by treatment (Figure 2). Light transmittance through desiccated hairy vetch relative to unobstructed PPFD exhibited a gradual increase as wavelength increased from 400 to 1100 nm. Live hairy vetch, however, reduced light transmittance from 400 to 700 nm but allowed greater transmittance of far-red radiation than desiccated hairy vetch.

*Table 1.* Weed density and biomass response to desiccated or live hairy vetch[a].

| Year | Hairy vetch treatment[b] | Weed density at weeks after desiccation 4 | 8 | 12 | Weed dry weight |
|---|---|---|---|---|---|
| | | no. $m^{-2}$ | | | g $m^{-2}$ |
| 1989 | None | 110 a | — | — | 307 a |
| | Desiccated | 82 a | — | — | 182 b |
| | Live | 17 b | — | — | 93 c |
| 1990 | None | 193 a | 191 a | 276 a | 418 a |
| | Desiccated | 54 b | 115 a | 216 a | 545 a |
| | Live | 1 c | 15 b | 62 a | 198 b |
| 1991 | None | 68 a | 128 a | 184 a | 654 b |
| | Desiccated | 101 a | 176 a | 146 a | 949 a |
| | Live | 1 b | 32 b | 56 a | 312 c |

[a]Values followed by different letters within the same column and year are significantly different according to the protected LSD test (P = 0.05). Square root transformed data were used for analysis of weed density but data were backtransformed for presentation.

[b]Hairy vetch was either desiccated with paraquat or permitted to remain alive until natural senescence at approximately week 6.

*Table 2.* Biomass of major weed species growing in desiccated or live hairy vetch[a].

| Year | Hairy vetch treatment[b] | Weed dry weight | | | |
|---|---|---|---|---|---|
| | | ECHCG | SETVM | SETLU | CYPES |
| | | g m$^{-2}$ | | | |
| 1990 | None | 28 a | 58 a | 180 a | 97 a |
| | Desiccated | 147 a | 137 a | 134 a | 42 a |
| | Live | 89 a | 46 a | 28 b | 28 a |
| 1991 | None | 110 a | 376 b | 32 a | 66 a |
| | Desiccated | 57 a | 853 a | 10 a | 11 a |
| | Live | 92 a | 199 c | 20 a | 1 a |

[a]Values within columns and years followed by the same letter are not significantly different according to the protected LSD test (P = 0.05).

[b]Hairy vetch was either desiccated with paraquat or permitted to remain alive until natural senescence at approximately week 6.

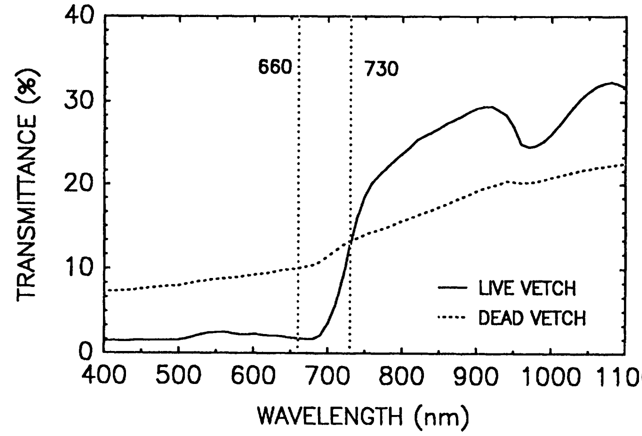


*Figure 2.* Light transmittance through desiccated or live hairy vetch as a function of wavelength at 14 d after desiccation in 1991. Light transmittance at a given wavelength is the ratio of measurements under hairy vetch divided by unobstructed measurements made above hairy vetch. Vertical reference lines are at 660 and 730 nm.

Reduced transmittance from 400 to 700 nm by live hairy vetch can be attributed to absorption of radiation in these wavelengths by chlorophyll.

The steeper slope for transmittance around 700 nm by live versus desiccated hairy vetch resulted in a lower red to far-red ratio (Table 4). Red to far-red ratios of 0.8 or greater produce near maximum conversion of phytochrome to the active form and stimulate phytochrome-mediated seed germination (4). Consequently, light transmitted through desiccated hairy vetch would shift phytochrome into the active form and permit germination. However, live hairy vetch reduced the red to far-red ratio to levels that would shift phytochrome to the inactive form and inhibit phytochrome-mediated seed germination. Barnyardgrass and giant foxtail have exhibited a light requirement for germination in previous research (1, 9), and therefore the shift in spectrum of transmitted light may be a major factor influencing weed suppression by live hairy vetch in this experiment.

Maximum soil temperature was reduced by desiccated and live hairy vetch in every year of the experiment (Table 5). Live hairy vetch reduced maximum soil temperature more than desiccated hairy vetch. The greatest reduction in maximum soil temperature by hairy vetch occurred during the hot, dry conditions of 1991. There was a trend toward a slight increase in minimum soil temperature under hairy vetch but this effect was significant only in 1990. These results agree with those of Bristow (3) who showed that mulches influence maximum soil temperature more than minimum soil temperature.

The soil temperatures observed under hairy vetch were not reduced sufficiently to prevent germination of weed seeds; at most, they could slow germination processes. Hairy vetch may have a greater influence on weed germination by affecting the daily amplitude between maximum and minimum temperatures (Table 5). Live and desiccated hairy vetch reduced soil temperature amplitude relative to bare soil. A diurnal temperature change of approximately 10 C is required for germination of some seeds (10) but it is unknown whether the species in this experiment had a temperature amplitude requirement.

*Table 3.* Frequency of sites under hairy vetch that received photosynthetic photon flux density (PPFD) at various levels relative to unobstructed sunlight. Measurements were made 2 to 3 wk after desiccation.

| Year | Hairy vetch treatment[b] | Frequency of sites at various PPFD categories[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | < 0.1% | 0.1–1% | 1–10% | 10–25% | 25–50% | > 50% |
| | | % | | | | | |
| 1989 | Desiccated | 0 | 19 | 44 | 29 | 6 | 2 |
| | Live | 25 | 69 | 6 | 0 | 0 | 0 |
| 1990 | Desiccated | 0 | 0 | 40 | 27 | 17 | 17 |
| | Live | 38 | 48 | 10 | 4 | 0 | 0 |
| 1991 | Desiccated | 0 | 4 | 52 | 19 | 17 | 8 |
| | Live | 15 | 65 | 21 | 0 | 0 | 0 |

[a]Frequency of sites in various light transmittance categories expressed as a percentage of 48 sites measured per treatment. Categories are expressed in units of percentage PPFD transmitted through hairy vetch relative to unobstructed sunlight.

[b]Hairy vetch was either desiccated with paraquat or permitted to remain alive until natural senescence at approximately week 6.

*Table 4.* Ratio of red to far-red photon flux density transmitted through hairy vetch[a].

| Hairy vetch treatment[b] | Red/far-red ratio | |
|---|---|---|
| | 6/18/90 | 5/22/91 |
| Desiccated hairy vetch | 1.08 (0.05) | 0.83 (0.17) |
| Live hairy vetch | 0.54 (0.05) | 0.15 (0.10) |

[a]Red to far-red ratio = (photon flux density at 660 nm) ÷ (photon flux density at 730 nm). The measured ratio was normalized to the standard value of 1.15 for unobstructed sunlight (8). Standard deviation is presented in parentheses.

[b]Hairy vetch was either desiccated with paraquat or permitted to remain alive until natural senescence at approximately week 6.

*Table 6.* Moisture content in the surface 2.5 cm of soil under hairy vetch during two droughty periods[a].

| Hairy vetch treatment[b] | Soil moisture content | |
|---|---|---|
| | 6/2/89 | 5/23/91 |
| | % | |
| None | 15.5 c | 12.1 b |
| Desiccated | 23.1 a | 18.5 a |
| Live | 20.0 b | 17.0 a |

[a]Values followed by different letters within columns are significantly different according to the protected LSD test (P = 0.05).

[b]Hairy vetch was either desiccated with paraquat or permitted to remain alive until natural senescence at approximately week 6.

Rainfall was relatively uniform and soils remained moist in all treatments throughout most of the 1989 and 1990 experiments. A brief period of soil drying occurred during 1989 and resulted in greater soil moisture content in the desiccated and live hairy vetch treatments compared to bare soil (Table 6) during this droughty period. Hot and dry weather conditions persisted throughout much of May and June of 1991. Soil moisture differences between the hairy vetch treatments and bare soil May 23, 1991 (Table 6) are typical of the soil moisture conditions throughout much of this period. Lower density and biomass of weeds in bare soil relative to the desiccated hairy vetch treatment in 1991 (Table 1) probably is the result of soil moisture differences between these treatments. Nitrogen and other nutrients released from desiccated hairy vetch residue also could have enhanced density and biomass in this treatment. Live hairy vetch extracted soil moisture but never reduced soil moisture to the level of bare soil.

This research demonstrated that live hairy vetch suppressed weeds longer and more effectively than desiccated hairy vetch. Environmental measurements suggest that greater light extinction, lower red to far-red ratio, and lower diurnal soil temperature amplitude under live hairy vetch than under desiccated hairy vetch residue could account for differences in weed suppression. Therefore, weed control can be maximized by keeping hairy vetch alive as long as possible in cropping systems. Competition between a live hairy vetch mulch and a crop would dictate the need for regulating the mulch according to the growth requirements of the crop. A live hairy vetch mulch may be especially useful for cropping systems with reduced herbicide inputs. The ideal system would permit live hairy vetch to suppress weeds during the critical period for weed competition early in the season and would synchronize the onset of maximum crop growth and canopy development with hairy vetch senescence.

*Table 5.* Average maximum and minimum temperature of the surface 5 cm of soil under hairy vetch during the first 28 d after desiccation[a].

| Year | Hairy vetch treatment[b] | Soil temperature | | |
|---|---|---|---|---|
| | | Max | Min | Amplitude |
| | | C | | |
| 1989 | None | 30.2 a | 20.6 a | 9.6 a |
| | Desiccated | 27.6 b | 21.4 a | 6.2 b |
| | Live | — | — | — |
| 1990 | None | 26.1 a | 15.2 c | 11.0 a |
| | Desiccated | 23.7 b | 17.0 a | 6.7 b |
| | Live | 20.3 c | 16.0 b | 4.3 c |
| 1991 | None | 34.0 a | 18.8 a | 15.3 a |
| | Desiccated | 27.9 b | 19.4 a | 8.5 b |
| | Live | 25.2 c | 19.3 a | 5.9 c |

[a]Values followed by different letters within the same column and year are significantly different according to the protected LSD test (P = 0.05).

[b]Hairy vetch was either desiccated with paraquat or permitted to remain alive until natural senescence at approximately week 6.

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