**Reduce Herbicide Use While Maintaining Crop Yield: Insights from a Crop Rotation Experiment**

Weed communities in three cropping systems suitable for the Midwestern USA were studied from 2017 through 2020 to examine how crop diversification and the intensity of herbicide use affected weed community diversity, stand density, and aboveground mass. A baseline 2-year cropping system with corn and soybean grown in alternate years was diversified with cool-season crops, namely oat and red clover, and alfalfa in 3-year and 4-year systems. Herbicides were not used in the the cool-season crops. This study was pursued to address the current gaps of information concerning how the density and biomass of weeds respond to different crop environments and weed management programs (Fried et al., 2012; Ryan et al., 2010).

Integrating chemical and cultural weed management tools resulted in an overall reduction in the amount of herbicide applied (Table 1). In all the studied rotations, the corn phases under low herbicide regime received banded herbicide application and interrow cultivation; the soybean phases received broadcast herbicide, and the oat and alfalfa phases (3-year and 4-year rotations) did not receive herbicide or cultivation. The reduction herbicide was associated with increases in weed density, aboveground mass, and community diversity. In the cool-season crop phases (oat, red clover, and alfalfa) of the 3-year and 4-year rotations, weed emergence increased, but weed biomass did not increase, as compared with the warm-season crops (corn and soybean). Increased weed abundance (Table 2) in the lower-herbicide regime (Table 1) was not associated with crop yield loss (Figure 1).

Table 1: Reduction in the amount of herbicide active ingredients applied in more diverse cropping systems as compared to a conventional 2-year corn and soybean system averaged from 2017 through 2020. The baseline was established at 2-year rotation of corn and soybean under conventional herbicide weed management. In the low herbicide weed management regime, corn received banded herbicide on top of crop rows and interrow cultivation. The minus sign in front of the percentages indicates the reduction in herbicide amount in the corresponding system as compared to the baseline.

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2-year | 3-year | 4-year |
| Conventional weed management | baseline | -33% | -50% |
| Low herbicide weed management | -13% | -42% | -57% |

Table 2: Weed abundance in three cropping systems. Zeroes in the Biomass and SE of biomass functions were due to rounding. Means and standard errors were obtained from two linear models describing the effects of crop identity (species and rotation in which they occurred) and weed management regimes on weed density and biomass, respectively. The numbers shown in the table were converted from g/m2 and plants/m2 to plant/yd2 and oz/yd2. Means were calculated crop identity, averaged over weed management regimes and years because only crop identity significantly affected the responses.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Crop | Rotation | Density (plant/yd2) | SE of density | Biomass (oz/ yd2) | SE of biomass |
| corn | 2-year | 6.4 | 3.5 | 0.1 | 0.1 |
| soybean | 2-year | 1.1 | 0.6 | 0.1 | 0.1 |
| corn | 3-year | 3.5 | 1.9 | 0 | 0 |
| soybean | 3-year | 0.5 | 0.3 | 0 | 0 |
| oat/red clover | 3-year | 31.4 | 17.1 | 0.5 | 0.5 |
| corn | 4-year | 6.0 | 3.3 | 0.1 | 0 |
| soybean | 4-year | 0.4 | 0.2 | 0 | 0 |
| oat/alfalfa | 4-year | 61.1 | 33.3 | 1.6 | 1.4 |
| alfalfa | 4-year | 54.6 | 29.8 | 0.6 | 0.5 |

A graph of different colored bars

Description automatically generated with medium confidence

Figure 2: Mean crop yields by rotation from 2017 to 2020. The color-coded bars show the experimental plots' crop yields (ton/ac). The error bars show the 95% confidence intervals. The solid horizontal lines show mean yields for Iowa, and dashed lines show mean yields for Boone County. Because county-specific alfalfa hay yields in 2019 and 2020 were unavailable at this writing, Boone County alfalfa yield (solid line) was averaged over 2017 and 2018 and Iowa hay yield was averaged over all counties in 2017 and 2018 and Iowa hay yield (dashed line) was averaged from all county-based values in 2017 and 2018 and two state-based values in 2019 and 2020.

The dominance of aggressive weed species such as common waterhemp and common lambsquarter tended to be more challenging in corn and soybean phases of the rotations than in oat, red clover, and alfalfa. Knowing the challenging weed species in the field and document the weed pressure in response to a weed management program would be useful to adjust management strategies to avoid outbreak. As weed seedbank density could be used as a sustainability indicator (Storkey and Neve, 2018; Liebman et al., 2021), having a record of weed seedbank composition over years can provide additional information for making long-term decisions about effective and sustainable weed management (Davis et al., 2005; Forcella et al., 1992; Forcella, 2003; Menalled et al., 2001).

The corresponding publication can be found at: <https://www.frontiersin.org/articles/10.3389/fagro.2022.848548>

The data can be found at: <<https://doi.org/10.25380/iastate.19111376>

The code for data analysis can be found at: <https://doi.org/10.5281/zenodo.5980943>

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