Iowa Organic Association

# ORGANIC RESEARCH RESULTS 2016

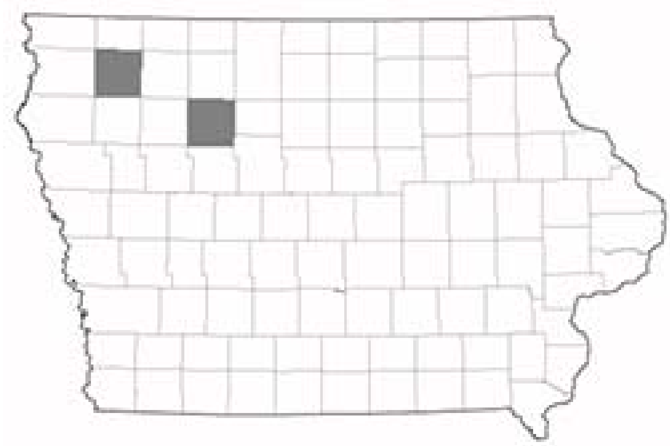
## EVALUATION OF ROTARY HOE FOR MECHANICAL WEED CONTROL IN ORGANIC OATS


### PROJECT OVERVIEW:

Weeds continue to challenge organic farmers, even in the small grain year of their crop rotation. Mechanical weed management may be an option. Two organic farmers growing oats without an underseeding compared rotary hoeing with no rotary hoeing to evaluate the impact on weed seedlings and biomass production in 2016. Oats were rotary hoed twice on two consecutive days three to four weeks post planting. Oat and weed plant stand counts were measured both pre and post rotary hoeing. Weed biomass was measured before oat harvest. Oat grain yields and test weights were measured in late July. Impact of the rotary hoe on weed seed production was not measured.

### KEY FINDINGS:

Rotary hoeing did not affect oat plant stands in the two trials. On both farms, rotary hoeing decreased early-season weed seedlings, but that only resulted in a reduction of weed biomass on one of the farms. Despite that reduction, oat grain yield and test weights were not affected by rotary hoeing. Oat yields and test weight average 112 bu/A and 32 lbs/A, respectively, across both treatments and both farms. Mechanical weed control with a rotary hoe may be a useful practice where no underseeding is planted with oats or other spring-planted small grain.


### COOPERATORS:

Darren Fehr, Rolfe & Dan Wilson, Paullina



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**WEB LINK:** http://bit.ly/IOAresearch


### PROJECT BACKGROUND:

Weed management is a major concern of organic crop producers (Walz, 2004). Much effort in the Midwest is centered on organic weed management in corn (*Zea mays* L.) and soybean [Glycine max (L.) Merr.], but little research addresses the possibilities for weed management in small grain crops included in organic rotations. Small grains, due to their near solid stand and lifecycle that differs from those of corn and soybean and are able to compete with weed species that would thrive in row crops (Teasdale et al., 2004). Weed control may still be an issue in small grains, but possibility for improved weed management using mechanical control in a small grain has not been well tested in the Midwest. Mechanical weed control includes hoeing, harrowing and/or flaming (Bàrberi, 2002). In Iowa and the upper Midwest, the rotary hoe is a common tool used for mechanical weed management in organic row crops and has some historical precedence regarding use in small grains (Hull, 1956). Because this type of mechanical weed control is already part of “the toolbox” of cultivation equipment among many organic farmers, we wondered about the efficacy of the rotary hoe when used in small grains. To date, there has been limited research on the efficacy of rotary hoeing in small grains. One study in New York compared multiple weed control tactics in spring oat (*Avena sativa* L.) including rotary hoeing, tine harrowing, herbicide application, and an untreated (not weeded) control (Mohler and Frisch., 1997). Results indicated no differences in grain yield among any of the treatments. Over three years of the study, the rotary hoe and tine-weeder were equally effective in controlling weed biomass, but neither were significantly different than the untreated (non-cultivated) control (Mohler and Frisch., 1997). Another study, in Finland, examined differences among inter-row hoeing, tine harrowing, chemical control, rotary hoeing and an untreated control in spring barley (*Hordeum vulgare* L.) (Lötjönen and Mikkola, 2000). Results indicated rotary hoeing to be the least effective of those tactics, as well as resulting in 6 percent lower yield than the untreated control.

The goal of this research was to determine the effícts of rotary hoeing in oats on weed populations, weed biomass and composition, oat grain yield and test weight in the Upper Midwest.

## METHODS:

Research was conducted on Darren Fehr's farm near Rolfe, Iowa, in Pochahontas County in NW, Iowa and on Dan Wilson's farm near Paullina, Iowa, in O'Brien County in NW, Iowa, in 2015. On both farms, experimental treatments consisted of rotary hoeing (RH) and no mechanical weed control (C). On both farms, oat were sown at 29 plants/ft2 using an equation to calibrate grain drills (Wiersma et al., 2005):

$$Desired\ Planting\ Rate\ (\frac{lb.}{acre}) = \frac{Desired\ Plant\ Stand\ \div (1 - expected\ loss(\%))}{\frac{\text{Seeds}}{\text{lb.}}\ x\ PLS}$$

$$PLS = Pure\ Live\ Seed$$

Predicted stand loss was estimated at 25% because of expected damage to seedlings during the hoeing. Each farmer determined oat seeds per pound by weighing 1000 seeds. Pure live seed (PLS) (germination x pure seed) was available from seed bag tags.

Both farms established five replicates of the treatments (2) in a randomized complete block design, totaling 20 plots. Oat varieties were different on the two farms, but field operations and timing were similar for both (Table 1). When oats were in the one to two fully emerged leaf stage, both farmers made two mechanical weed control passes parallel to the crop row with their rotary hoes; one pass per day for two consecutive days. Driving speed was approximately 10 miles per hour and soil conditions on all days of hoeing were windy and dry. Weed and oat plant densities were measured both before and after rotary hoeing at both farms (Table 1). Five subsamples were taken from each plot (both before and after rotary hoeing) by walking in an M-W pattern across the unit and randomly selecting a subsample area using a 0.5 m2 quadrat. Similar, late-season measurements were taken when oat plants were in the early dough (Z8.0) stage of development (Zadoks et al., 1974). All vegetative material was removed from the ground up using garden shears. Weed biomass was sorted into grasses and broadleaves, dried at 140°C to a constant weight, and weighed.

**Table 1. Operation timing, oat variety and underseeding species and quantities**

| Farmer | Variety | Planting Date | Rotary Hoeing Dates | (Swathing Date) Harvest Date |
|---|---|---|---|---|
| Fehr | Deon | 4/13/2016 | 5/5/2016, 5/6/2016 | 7/25/2016 |
| Wilson | Shelby 427 | 4/8/2016 | 5/6/2016, 5/7/2016 | (7/21/2016), 7/22/2016 |

Collaborating farmers measured grain yield by harvesting one combine-width strip down the middle of each plot and weighing grain in weigh wagons. Yield measurements were converted to a 32-pound per bushel standard. Grain moisture content and test weight were determined using a DICKEY-john 2500-AGRI Grain Analysis Computer. Reported yields were normalized to 13% moisture.

Data was analyzed using the GLIMMIX procedure in SAS 9.4 (SAS Institute, 2013) to evaluate the effect of rotary hoeing on grain yield and test weight, plant and weed counts, and weed biomass. Factors were considered to be significant at $P \leq 0.05$.

## RESULTS & DISCUSSION:

Total rainfall (by month) and oat growing degree days (GDD, base 32°F) are given for Pocahontas, IA (13 miles from Fehr's farm) and Primghar, IA (11 miles from Wilson's farm). Rainfall was near the long-term average for the growing season and growing degrees days just below average near Fehr's. Near Wilson's farm however, rainfall was two inches below the long-term average and growing degrees day accumulations was 10 percent below average for the growing season (Table 2).

**Table 2. Rainfall and oat growing degree days (GDD, base 32°F) for 2016 and long term averages for Pocahontas and Primghar.**

| | Pocahontas[a] | | | | Primghar[a] | | | |
|---|---|---|---|---|---|---|---|---|
| | Rainfall (in.) | | GDD | | Rainfall (in.) | | GDD | |
| Mon. | 2016 | Avg. | 2016 | Avg. | 2016 | Avg. | 2016 | Avg. |
| Mar. | 2.19 | 1.95 | 337 | 202.3 | 2.43 | 1.68 | 391 | 220.1 |
| Apr. | 4.03 | 3.04 | 537 | 498 | 4.45 | 2.83 | 586 | 519.4 |
| May | 3.63 | 3.89 | 863.5 | 860.9 | 4.61 | 3.73 | 905 | 879.5 |
| Jun. | 0.89 | 4.68 | 1218 | 1112 | 3.85 | 4.68 | 1235 | 1121 |
| Jul. | 7.12 | 4.05 | 1257 | 1252 | 3.54 | 3.82 | 1287 | 1267 |
| Total | 17.9 | 17.6 | 4212 | 3925 | 18.9 | 16.7 | 4404 | 4007 |

[a]Data from Pocahontas and Primghar were accessed from the Iowa Environmental Mesonet (2016).

[b]Avg. represents average values from 1951-2015.

### Oat Populations

There were no effects on oat plant populations as a result of rotary hoeing at either farm. As expected, oat populations before rotary hoeing were the same at both farms. Population counts declined later in the growing season, but in both rotary hoe and control treatments (Figure 1).

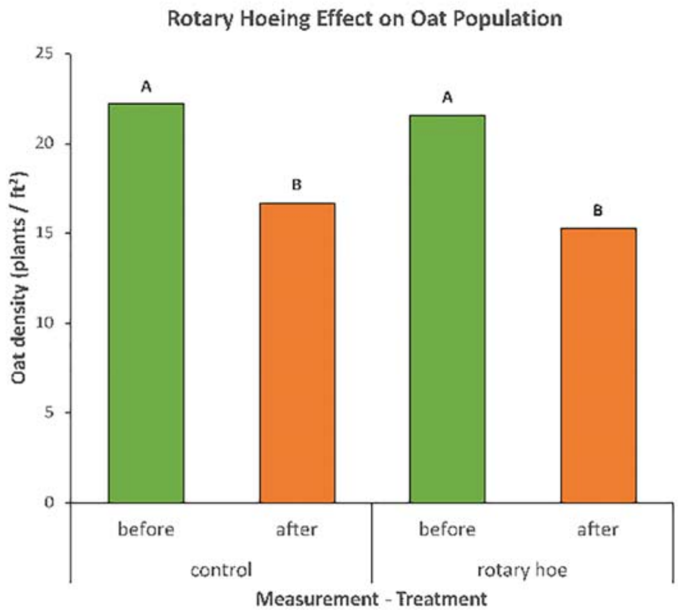


Figure 1. Rotary hoeing (RH) vs. control (C) effect on oat population. Data were recorded in early May immediately before rotary hoeing and approximately one and a half weeks after rotary hoeing. For each farm, columns with different letters are significantly different ($P < 0.05$).

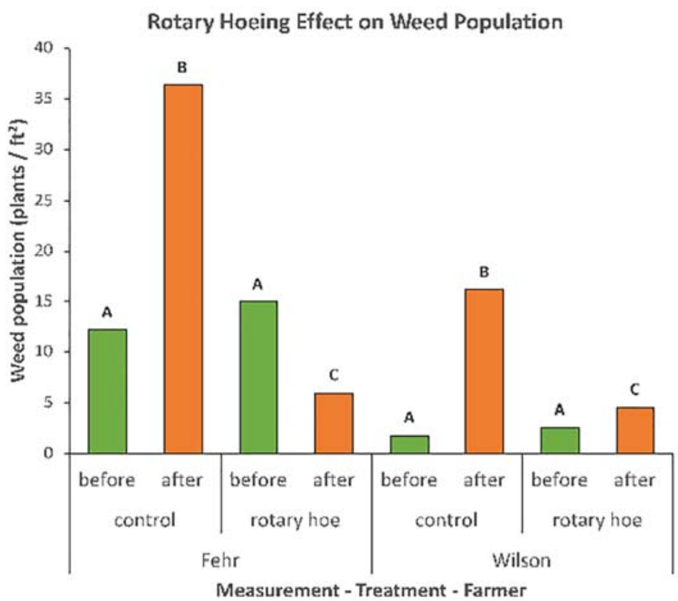


Figure 2. Rotary hoeing (RH) vs. control (C) effect on weed population. Data were recorded in early May immediately before rotary hoeing and approximately one and a half weeks after rotary hoeing. For each farm, columns with different letters are significantly different ($P < 0.05$).

**Weed Populations**

Overall weed populations and biomass were higher at the Fehr farm than at Wilson's (Fig 2., Fig 3.). Even so, rotary hoeing significantly reduced weed populations at both farms. At Fehr's farm, between pre and post rotary hoeing, the weed population increased almost 200 percent in control plots, but was decreased by 60 percent in the rotary hoed plots. The weed population was approximately six times lower in rotary hoed plots than in control plots at the "after" measurement (Fig. 2). At Wilson' farm, weed populations in both treatments increased post rotary hoeing, perhaps due to late seedling emergence. Even so, from before to after measurements, weed populations were decreased by three and a half times----from 17 plants / m 2 to 5 plants / m2 as a result of rotary hoeing. (Fig. 2).

**Weed Biomass and Composition**

The effects of the rotary hoeing treatment on weed biomass were different at each farm. At Fehr's farm, the weed species of greatest abundance were Pennsylvania smartweed (*Polygynum pennsylvanicum* L.), giant foxtail (*Setaria faberi*) and yellow foxtail (*Setaria pumila*). Grassy weed biomass was not affected but broadleaved weed biomass was reduced almost 60 percent over the control. Overall, total weed biomass was reduced by one third as a result of rotary hoeing (Fig. 3). At Wilson's farm, where common cocklebur (*Xanthium strumarium* L.), lamb's quarters (*Chenopodium album* L.) and crab grass (*Digitaria sanguinalis* L.) were the most prevalent species, rotary hoeing had no statistically significant effect on either broadleaves, grassy weeds, or total biomass throughout the season.

**Grain Yield and Test Weight**

There were no differences in oat grain yield or test weight between rotary hoed and control treatments at either farm.

**Table 3. Oat grain yield and test weight at Fehr and Wilson farms under control and rotary hoed treatments.**

| | Farm | | | |
|---|---|---|---|---|
| | Fehr | | Wilson | |
| | Treatment | | | |
| | Control | Rotary Hoed | Control | Rotary Hoed |
| Yield (bushels / acre) | 115a[a] | 108a | 109a | 115a |
| Test weight (lbs. / bushel) | 32a | 32a | 32a | 32a |

[a]Within rows, by farm, treatment values with different letters are significantly different.

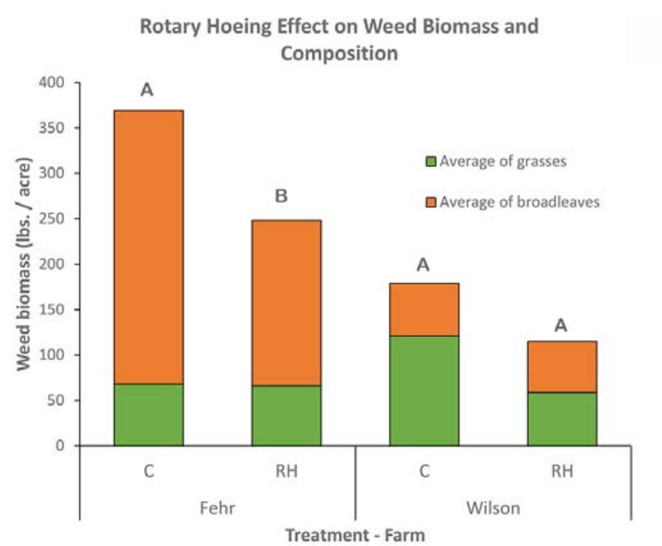


Figure 3. Rotary hoeing (RH) vs. control (C) effect on weed biomass and composition. Data were recorded in early July at both farms when oat plants were in the soft dough stage. For each farm, columns with different letters are significantly different ($P < 0.05$).

Average yield at both farms for both rotary hoeing no rotary hoe treatments was 112 bushels/A; test weight averaged 32 pounds per bushel (Table 3).

**CONCLUSIONS & MANAGEMENT IMPLICATIONS:**

Though the farmers in this study were instructed to perform rotary hoeing passes based on crop stage, truly effective weed management involving mechanical cultivation requires careful examination of weed stage as much, if not more so, than crop stage. In a spring cereal like oats, this may present a challenge as mechanical weed control even earlier in crop development might be as or more detrimental to yield potential as the weed pressure and delaying cultivation further might risk even greater ineffectiveness with respect to the rotary hoe (Rasmussen et al., 2009).

At Fehr's farm, rotary hoeing was effective in reducing both weed population and broadleaf weed biomass. The bulk of this biomass was Pennsylvania smartweed, a shallow-rooted early emerging annual that was more readily uprooted at cotyledon and two-leaf stages when plants were under 0.25 inches in height. Giant ragweed, in patches, at Fehr's farm and was not affected at all by rotary hoeing. In comparison, at Wilson's farm, the lack of efficacy in reducing broadleaf weeds may have been due to the fact that the majority of the broadleaf weed biomass was composed of common cocklebur, another early-emerging weed species. Cocklebur, unlike Pennsylvania smartweed, is noted for emerging from deeper in the soil profile and having a strong taproot and thick leaves, making it challenging species when using mechanical weed control (Buhler et al., 1993).

While the rotary hoe may have helped reduce potential additions to the weed seedbank (broadleaves at Fehr's farm and grasses at Wilson's), in these trials, it did not provide clear benefits to crop yield and had mixed results with respect to weed control. Rotary hoeing is not an appropriate practice for farmers who plant an underseeding with oats. They will have better luck with mid-season weed control such as tillage and/or mowing after grain harvest. Cooperator Dan Wilson summed up his experience with this research saying, "Based on these results, we probably won't rotary-hoe in the future, mainly because we usually grow our oats with an underseeding. But any research we can get on how to crop a third crop is beneficial".

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