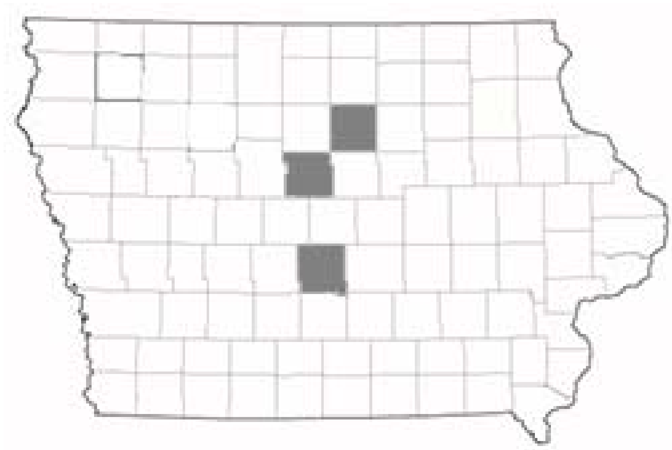
Iowa Organic Association

# ORGANIC RESEARCH RESULTS 2015-2016

## OPTIMAL OAT PLANT POPULATIONS FOR ORGANIC CROPPING SYSTEMS

### PROJECT OVERVIEW:

Optimal seeding rates are important for all crops and may differ in organic vs. non-organic cropping systems. Oats are typically seeded by bushels or pounds/A while corn and soybeans are planted by seed count. Oats, however, may vary from 11,000 to 17,000 seed/lb. We wanted to test the effect of a range of oat seeding rates, by seed count, in organic crop rotations. In 2015 and 2016, three organic farmers, Doug Alert, Aaron Lehman, and Ortrude Dial, tested three seeding rates, accurately calibrated at 22, 29, and 36 plants per $ft^2$ for their impact on oat grain yield and test weight. Late underseeding and weed biomass were also measured six weeks following grain harvest on two of the three cooperating farms.



### KEY FINDINGS:

Oat yields were fairly consistent across farm sites and years and averaged 97 bu/A. Oat seeding rate had no impact on either grain yield or test weight. The different seeding rates also did not affect either legume or mixed grass/legume underseeding biomass at the two farms where this was measured. Late-season weed biomass was lower at the mid seeding rate, 29 seeds/$ft^2$ when compared with the lower seeding rate at one farm site. It appears that organic farmers can use lower seeding rates to achieve optimal yields, while savings up to $16.50 per acre in seed cost compared with the highest seeding rate.

### COOPERATORS:

Doug Alert, Hampton; Aaron Lehman, Polk City and Ortrude Dial, Williams

**FUNDED BY:** Ceres Trust

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

### PROJECT BACKGROUND:

Spring oats (*Avena sativa* L.) are an essential part of many organic row-crop systems in the U.S. Corn Belt. Both grain and straw are important to the profitability of oats. Ecologically, oats' role is essential to suppress weeds and aid in legume establishment for nitrogen contribution in multi-year rotation. In addition to these benefits, the planting and harvest schedule of oats differs from that of corn and soybean, helping spread the workload for farmers. Unfortunately, oats are often the financial weak link in diversified crop rotations (Delate et al., 2003). This is due to a combination of price, yield, and grain quality (test weight), which is often insufficient (<36 lb/bu) for the food-grade market. As a result, oats receive little agronomic attention from farmers or researchers. Both limited institutional support and a loss of generational knowledge about small grains production is limiting information to aid farmers' decision-making (Larsen, 2015). The most recent Iowa State University Extension publication providing basic information on oat agronomy was released over two decades ago (Hansen, 1992). Annual variety trials still take place at limited sites, and fungicides for rust control have been tested by both Iowa State University and Practical Farmers of Iowa (Gailans et al., 2015). An observational study conducted by the author conducted in the 2014 and 2015 growing seasons with over 40 organic farmers across Iowa indicated that there is limited consensus about basic agronomic questions, such as what optimal seeding rates should be.

Some Midwestern data shed light on that question. Research reported in 1992 (Hansen) examined the effects of different seeding rates for conventional oats. Four seeding rates were tested: 15, 30, 45 and 60 seeds per ft2. Oat grain yields were 36.5, 40, 39.9 and 38.9 bushels per acre, respectively, indicating a yield plateau at about 30 seeds per ft2. More recent data from Wisconsin tested the effects of medium (28 seeds per ft2) and high (34 seeds per ft2) seeding rates on grain yield and quality, determining no significant difference on either yield or test weight between the two treatments (Mourtzinis et al., 2015). Minnesota's organic management guide suggests that optimal yields would be achieved at 28-30 plants per ft2 and advocated the use of a targeted population in place of seeding by bushel or seeds per acre

(Wiersma et al., 2005). We had three questions about oat populations for current organic production systems:

1. What is the economically optimal crop population for organic oats in Iowa to help farmers improve profitability?
2. What is the effect of different oat populations on weed species and their biomass that develop under the oat canopy? We theorized that high oat populations might provide more competition and suppress weed growth better than low populations in organic rotations.
3. Do higher oat plant populations adversely affect legume and forage underseedings due to competition?

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

| Farmer | Oat cultivar | Seeds/lb | Oat planting rate | Forage/ legume underseeding | Forage/ legume seeding rate | Planting date | (Swathing date) Harvest date |
|---|---|---|---|---|---|---|---|
| | | | lb/A | | lb/A | | |
| Alert | Saber | 14,106 | L*-84.5<br>M-111.5<br>H-138 | Alfalfa<br>Orchardgrass | 12<br>5 | 4/14/2015 | (8/8/2015)<br>8/15/2015 |
| Lehman | Saber | 14,106 | L-84.5<br>M-111.5<br>H-138 | Mammoth red clover | 12 | 3/31/2015 | 7/19/2015 |
| Dial | Shelby 427 | 14,496 | L-85<br>M-116.5<br>H-137 | Crimson clover<br>Medium red clover | 10.5<br>1.5 | 4/15/2016 | (7/25/2016)<br>7/26/2016 |

* L - Low rate; M - Medium rate; H - High rate.

Objectives of this research were to assess in organic crop rotations, the impact of seeding rate on oat grain yield, test weight (TW), forage/legume underseeding biomass and weed biomass. These four factors represent major sources of profitability or loss for oats.

Table 2. Rainfall and oat growing degree days (GDD, base 32°F) for 2015 and 2016 and long term averages for Hampton

| | Hampton[a] | | | | Ankeny[a] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rainfall (in.) | | GDD | | Rainfall (in.) | | GDD | | Rainfa |
| Mon. | 2015 | Avg. | 2015 | Avg. | 2015 | Avg. | 2015 | Avg. | 2016 |
| Mar. | 0.5 | 1.94 | 258.5 | 180.9 | 0.67 | 1.91 | 290.5 | 244.1 | 0.3 |
| Apr. | 4.62 | 3.38 | 515 | 456.3 | 2.61 | 3.24 | 560.5 | 525.1 | 3.85 |
| May | 4.45 | 4.42 | 820 | 809.7 | 4.5 | 4.3 | 857.5 | 861.9 | 5.61 |
| Jun. | 7.6 | 5.29 | 1063 | 1057.3 | 10.44 | 5.03 | 1075.5 | 1098.4 | 4.44 |
| Jul. | 4.72 | 4.77 | 1166 | 1197.9 | 5.71 | 4.21 | 1204.5 | 1243.5 | 3.86 |
| Aug. | 7.93 | 4 | 1094 | 1138.2 | 3.82 | 3.98 | 1120 | 1187.4 | 9.76 |
| Total | 29.8 | 23.8 | 4916.5 | 4840.3 | 27.8 | 22.7 | 5108.5 | 5160.4 | 27.8 |

[a]Data from Hampton, Ankeny and Webster City were accessed from the Iowa Environmental Mesonet (2016).

## METHODS:

Research was conducted on Doug Alert's farm near Hampton, in Franklin County in NC Iowa, Aaron Lehman's farm near Polk City in Polk County in Central Iowa in 2015 and Ortrude Dial's Farm near Williams, in NC Iowa in 2016. On each farm, spring oats were sown at three populations: 22, 29 and 36 plants per ft2, which will be referred to as low, medium and high, respectively. Alert and Lehman planted the variety 'Saber'; Dial planted the variety 'Shelby 427' Each of the three farmers included an underseeding of their choice, sown at a constant rate at each site and across the three populations (Table 1). All three farms used the following equation (adapted from Wiersma, Moncada, & Brakke, 2005) to calibrate their drills for planting the desired populations:

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

$$PLS = Pure\ Live\ Seed$$

Expected loss was estimated at 15% and seeds per pound were determined at the Iowa State University Seed Science Laboratory. Germination percentage and pure seed were obtained from seed bag tags and pure live seed (PLS = % germ x pure seed) calculated. Operation timing and pounds of seed sown per acre were also recorded, as this number differed based on the seeds per pound count of the specific oat variety (Table 1).

Each cooperating farmer established five replicates of the three populations in a randomized complete block design, creating a total of 45 plots. Plot widths were two times the width of farmers' drills and 500 ft. long.

Hand-harvested measurements were made post-harvest to determine the potential effects of the treatments on underseeding and weed biomass. These measurements were taken approximately six weeks after grain harvest at the Lehman and Alert farms. Underseeding and weed biomass samples were not taken on the Dial farm due to disturbance of the stand from a liquid manure application. At each farm, five subsamples were taken from each plot by walking in a 'W' pattern across the plot and randomly selecting 5.4 ft2 subsample areas (photo reference?). Using 5.4 ft2 frames, all vegetative biomass was removed at ground level with garden shears and placed into paper bags. Samples were sorted by underseeding and weed biomass and dried at 140 °F to a constant weight (Table 2).

Cooperating farmers collected oat grain yields from one combine pass taken through the center and for the length of each plot. Grain from harvested strips was weighed in weigh wagons. Subsamples of approximately one quart were taken from each harvested strip to estimate grain moisture and test weight with a DICKEY-john 2000-AGRI Grain Analysis Computer. Reported yields were normalized to 13% moisture and grain yields were converted to a 32 pounds per bushel standard.

David Weisberger analyzed data using the GLIMMIX procedure in SAS 9.4 (SAS Institute, 2013) to evaluate the effect of oat population and farm site on grain yield, test weight, under-seeding biomass and weed biomass. Factors were considered to be significant at $p \leq 0.05$.

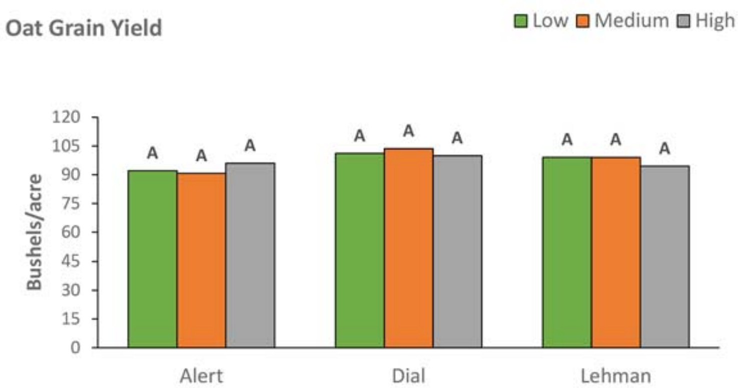



Figure 1. Oat grain yield. Data were recorded by combine harvest in the first week of August for Alert, the third week of July for Lehman (both 2015) and the fourth week of July for Dial (2016). For each farm, columns with different letters are significantly different (P < 0.05).


Figure 2. Oat grain yield at three populations and their associated seed costs. Grain yield was not significantly different at P < 0.05. Associated seed costs indicate that the net return to grower would be greatest at the lowest population treatment, based on these three site years of data.

## RESULTS & DISCUSSION:

Total rainfall (by month) and oat growing degree days (GDD, base 32°F) are given for Hampton, IA (5 miles from Alert's farm), Ankeny, IA (11 miles from Lehman's farm) and Webster City, IA (17 miles from Dial's farm) (Table 3). Rainfall throughout the growing season was approximately 25 percent higher than the long-term average at all farms. Growing degree day accumulations were near average at each site.

### Grain Yield

Oat population had no significant effect on grain yield at any of the three farms (Fig. 3). Mean yield at the three cooperating farmers were 93 bushels/acre (Alert), 97 bushels/acre (Lehman) and 102 bushels/acre (Dial). These results indicate that within the range of populations tested in these site years, equivalent yields can be attained at lower populations with a lower cost. Seed costs averaged over all farms were $26.66, $35.77 and $43.29 for the low, medium and high populations respectively. Net returns were greatest at the lowest oat plant population tested. Savings between the low and high populations in these particular situations averaged $16.63/acre.

### Test Weight

Oat population also had no significant effect on test weight at any of the farm sites. However, environment (different

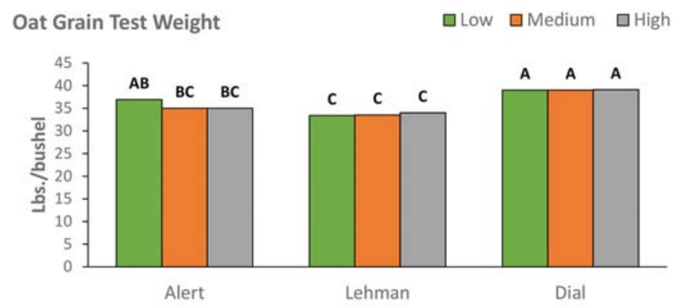



Figure 3. Oat grain test weight. Data were recorded at harvest in the first week of August for Alert, the third week of July for Lehman, (both 2015) and the fourth week of July for Dial (2016). For each farm, columns with different letters are significantly different (P < 0.05).

farms) produced significantly different test weights (p < 0.001) (Fig. 3). Numerically, the highest test weights occurred at the low population at Alert's farm (36.9 pounds/bushel), across all populations at Lehman's farm (33.5 pounds/bushel) and across all populations at Dial's farm (39 pounds/bushel). It is difficult to determine the precise effects of environmental factors on test weight. Each farm was at a different latitude, had different planting dates (Table 1.) and was subject to different amounts and patterns of precipitation, heat units (Table 2.) and pest pressure (diseases, insects and weeds). In general, heavier oat test weights are associated with cooler temperatures, especially during grain fill, usually experienced with earlier planting dates and at more northern latitudes (Doehlert et al., 2001). This may account for differences among the farm environments in this study.

### Underseeding and weed biomass

Underseeding and weed biomass were measured six weeks after grain harvest at both sites (Alert and Lehman) in 2015 but not in 2016 at Dial's. Oat populations did not affect underseeding biomass, but weed biomass quantities did differ between Alert's and Lehman's farms and among treatments at Lehman's farm. Alert overall had greater underseeding biomass than Lehman (410 and 314 pounds/acre, respectively) (Fig. 1) Alert planted an additional 5 lbs./A of forage/cover crop seed compared to Lehman (Table 1), and this site was sampled three weeks later than Lehman's allowing for additional plant growth.

At Alert's farm there was no difference among population treatments on weed biomass. At Lehman's farm, the lowest population had the highest weed biomass per acre. The medium population had the significantly lowest quantity of weed biomass per acre (Fig. 2). Lehman normally mows his oat stubble after oat harvest to mechanically control weeds that grow under the oat canopy, as well as to more evenly shred and distribute the remaining oat straw. He did not mow during this trial to facilitate the late –season biomass harvest for this study. It is impossible to verify if or the degree to which the lack of this mowing operation may have affected our results, but it warrants mentioning. At both farms, yellow foxtail (*Setaria pumila* (Poir.) Roem & Schultgiant), giant foxtail (*Setaria faberi* L.) and Canada thistle

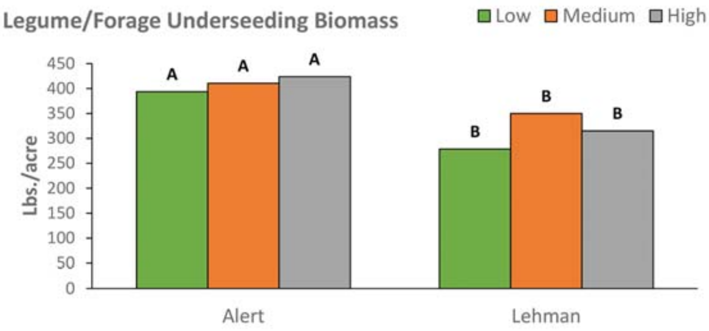



Figure 4. Legume/forage biomass. Data were recorded approximately six weeks after grain harvest, which was during the third week of September for Alert and at the end of August for Lehman (both 2015). For each farm, columns with different letters are significantly different (P < 0.05).

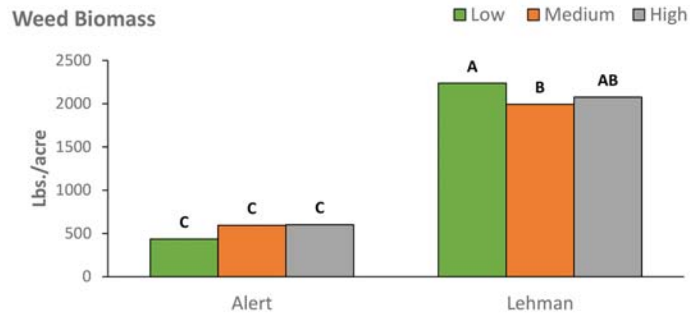



Figure 5. Weed biomass in the third week of September for Alert and at the end of August for Lehman (both 2015), approximately six weeks after oat grain harvest. For each farm, columns with different letters are significantly different. (P < 0.05).

(*Cirsium arvense*) were the most abundant weeds in the legume/forage samples.

## CONCLUSIONS & MANAGEMENT IMPLICATIONS:

These data support both older and more recent research with conventional oats on yield and test weight response to a range of seeding rates for Midwest growing conditions (Hansen, 1992, Mourtzinis, Conley, & Gaska, 2015). In this study, there were no significant effects of oat plant population on grain yield or test weight indicating the potential for lowering seeding rates, while maintaining productivity and profitability (Question 1). Likewise, there was little to no population effect on weed and legume biomass, meaning that weed suppression and legume establishment may be maintained with the economical optimal oat population (Questions 2 and 3).

While savings on seed costs are possible with a lower population, it is important to calculate seeds per pound counts and recalibrate grain drills accordingly on a yearly basis. Says cooperator Aaron Lehman, "There's quite a bit of variance in seed size in oats. Knowing that, I found that I would probably save some money if I made a practice of figuring out how many seeds there are per pound and using that, rather than bushel sper acre as my basis for planting. It will vary your planting rate quite a bit if you don't know exactly how many seeds per pound you have". Irrespective of the results of the trial, Aaron's insight also highlights the benefits of calibrating a grain drill to achieve a desired population, and his future plans to adopt this practice "It's something I'll put into practice in the coming years — it's definitely worthwhile".

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