## 2011 SPRING WHEAT WEED CONTROL STRATEGIES

Many organic grain growers in the northeast struggle with weed issues especially in spring wheat. Weed competition is often a problem in spring wheat due to many factors. Some of those factors include weed seed disturbance from spring tillage and weed germination at the same time as crop germination. With this in mind, the University of Vermont Extension, along with the University of Maine, has begun conducting trials to evaluate the effects of different weed control methods in spring wheat. In 2011, the study was continued to develop strategies that will minimize weed competition while maintaining yield and quality parameters to successfully produce high-quality bread wheat. The management practices evaluated include variable row spacing, elevated seeding rates, and mechanical cultivation with a tineweeder and/or inter-row hoe.

# MATERIALS AND METHODS

The 2011 study was conducted at Borderview Research Farm in Alburgh, VT (Table 1). The experimental design was a randomized complete block with four replications. The treatments were six weed management practices (Table 2). All "Standard" plots had a row spacing of six inches; all plots marked with a "+" symbol were tineweeded twice after emergence; high-density ("HD") plots had an elevated seeding rate of 200 lbs per acre; narrow and wide plots have varied row spacing (4.5 and 9 inches, respectively); the "Standard 2/3 and Broadcast 1/3" plots were planted with both a grain drill (2/3 of the seed) and by broadcasting (1/3 of the seed) to achieve a denser stand. The plot size was 5' x 25'. The soil was a rocky Benson silt loam, and the previous crop was organic corn. In the spring, the seedbed was prepared with a chisel plow, disk, and spike-toothed harrow. Each plot was seeded with the spring wheat variety AC Superb. Plots were also seeded with Ida Gold mustard (*Sinapis alba* L.) at a rate of 50 lbs per acre to ensure weed competition in the trial. Wheat was planted on 12-May with either a John Deere 750 grain drill (for all of the plots with six-inch row spacing) or, in the case of narrow and wide plots, a Kverneland Accord DL pneumatic seed drill.

**Table 1. Trial information and agronomic practices for the 2011 weed control study, Alburgh, VT.**

| Location | Borderview Farm - Alburgh, VT |
|---|---|
| **Soil type** | Benson rocky silt loam |
| **Previous crop** | Organic corn |
| **Spring tillage operations** | Chisel plow, disk, spike-toothed harrow |
| **Seeding rates** | 135 lbs $ac^{-1}$, 200 lbs $ac^{-1}$ |
| **Wheat variety** | AC Superb |
| **Weed seed** | Ida Gold mustard, 50 lbs $ac^{-1}$ |
| **Replicates** | 4 |
| **Planting date** | 12-May |
| **Harvest date** | 17-August |
| **Harvest area** | 5'x25' |

**Table 2. Treatments in the weed control study, 2011, Alburgh, VT.**

| Treatment | Row spacing inches | Seeding rate lbs ac$^{-1}$ | Tineweeding date | Inter-row cultivation |
|---|---|---|---|---|
| Standard | 6.0 | 135 | - | - |
| Standard + | 6.0 | 135 | 5/23 and 6/3 | - |
| Standard HD + | 6.0 | 200 | 5/23 and 6/3 | - |
| Standard 2/3 & Broadcast 1/3 + | 6.0 | 135 | 5/23 and 6/3 | - |
| Narrow HD+ | 4.5 | 200 | 5/23 and 6/3 | - |
| Wide + | 9.0 | 135 | 5/23 and 6/3 | 6/24 |

Each plot, with the exception of the "Standard" plots, was cultivated with a tineweeder at 11 and 22 days after planting (DAP). This type of cultivation is designed to disturb and uproot weed seedlings in their "white thread root" stage, causing desiccation and death. At each tineweeding event, wheat and mustard plants, as well as annual and perennial grasses and broadleaf plants, were tallied in a specific area before and after tineweeding. This allowed for calculations of wheat mortality as well as reduction in mustard, as well as annual grasses and broadleaf plants. At the time of both tineweeding events, few to no perennial weeds were found; the reductions in perennial weeds are therefore not reported.

In addition, the plots with nine-inch row spacing were cultivated with a Schmotzer inter-row hoe on 24-June. The Schmotzer hoe, imported from Germany, is a manually-guided, rear-mounted implement that can be used to cultivate in between wide rows of wheat (Fig. 1). This allows weed control to take place later in the growing season, after plants are well established.

**Figure 1. Schmotzer hoe cultivation between rows of wheat.**

Plot areas were harvested on 17-August with an Almaco SPC50 plot combine with a 5' head. After harvest, a small Clipper fanning mill was used to clean the wheat seed, thus removing mustard seed and other debris. After cleaning the wheat and mustard seed were weighed separately to calculate yields.

Approximately one pound of each sample was used as a subsample to test for quality, and a portion of this was ground into flour using a Perten LM3100 Laboratory Mill. At the University of Vermont's Cereal Testing Laboratory, the Perten Inframatic 8600 Flour Analyzer was used to determine moisture content and crude protein of each sample. In bread wheat, crude protein, which affects gluten strength and loaf volume, is ideally 14-15%. Falling number was determined with a Perten FN 1500 Falling Number Machine (AACC Method 56-81B, AACC Intl., 2000). The falling number is related to the level of sprout damage that has occurred in the grain, and is measured by the number of seconds it takes for a stirrer to fall through a slurry of flour and water to the bottom of a tube. Falling numbers greater than 350 indicate low enzymatic activity and good quality wheat. A falling number lower than 200 indicates high enzymatic activity and poor quality wheat. Analysis of deoxynivalenol (DON), which is produced by mycotoxins, was conducted with a Veratox DON 5/5 Quantitative Test from the NEOGEN Corporation. This test has a detection range of 0.5-5.0 ppm. Samples with DON levels greater than 1.0 ppm are considered unsuitable for human consumption.

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. All data was analyzed using a mixed model analysis where replicates were considered random effects. At the bottom of each table a Least Significant Difference (LSD) value is presented for each variable (e.g. yield). LSDs at the 10% level (0.10) of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two values. Treatments listed in bold had the top performance in a particular column; treatments that were not significantly lower in performance than the highest value or top performing treatment in a particular column are indicated with an asterisk.

In the example at right, treatment C is the top-performer and is significantly different from treatment A but not from treatment B. The difference between B and C is equal to 729, which is less than the LSD value of 889. This means that these treatments did not differ in yield. The difference between A and C is equal to 1454, which is greater than the LSD value of 889. This means that the yields of these two treatments were significantly different from one another.

| **Variety** | **Yield** |
|---|---|
| A | 3161 |
| B | 3886* |
| C | **4615*** |
| **LSD** | **889** |

# RESULTS

Using data from a weather station in close proximity to Borderview Farm in Alburgh, VT, weather data is summarized in Table 3. The 2011 growing season was slightly warmer than normal, with monthly temperatures between May and August an average 2.1°F higher than normal. There were also 11.5 more inches of precipitation than average during this period. Using 32°F as a base temperature, there were 4,349 Growing Degree Days accumulated in the May-August months, 215 more than the 30-year average.

**Table 3. Summarized weather data for 2011 – Alburgh, VT.**

| South Hero, VT (Alburgh) | May | June | July | August |
|---|---|---|---|---|
| Average Temperature (°F)± | 58.7 | 67.1 | 74.4 | 70.4 |
| Departure from normal | 2.1 | 1.3 | 3.3 | 1.6 |
| | | | | |
| Precipitation (inches)* | 8.67 | 3.52 | 3.68 | 10.23 |
| Departure from normal | 5.35 | 0.09 | -0.29 | 6.38 |
| | | | | |
| Growing Degree Days (base 32°F) | 826 | 1088 | 1314 | 1121 |
| Departure from normal | 63.6 | 74.1 | 104 | -26.3 |

± Average temperature for August is taken from Burlington, VT.
* Precipitation for May-July is taken from Burlington, VT.
Based on National Weather Service data from cooperative observation stations in South Hero, VT. Historical averages are for 30 years of data (1971-2000).

Table 4 shows effects of tineweeded treatments on the reduction of weeds, as well as inadvertent wheat mortality resulting from tineweeding. The "Standard" plots, which were not tineweeded and therefore not included in the statistical analysis. There was no significant difference in average wheat mortality by treatment, though the treatment "Standard 2/3 & Broadcast 1/3 +" (two seeding methods), had the highest mortality (4.2 plants), though not statistically significant.

**Table 4. Average mortality and weed reduction in spring wheat after tineweeding events.**

| Tineweeded treatment | Wheat mortality | Mustard weed reduction | Annual grass weed reduction | Annual broadleaf weed reduction |
|---|---|---|---|---|
| | # plants | % | % | % |
| Standard + | **0.0** | 33.5 | 47.0 | 50.0 |
| Standard HD + | 3.4 | 44.1 | **67.7** | **79.3** |
| Standard 2/3 & Broadcast 1/3 + | 4.2 | **51.3** | 42.8 | 52.7 |
| Narrow HD + | 1.3 | 35.2 | 44.5 | 47.4 |
| Wide + | 1.8 | 47.8 | 55.6 | 49.4 |
| LSD (0.10) | NS | NS | NS | NS |
| Trial Mean | 2.1 | 42.4 | 51.5 | 55.8 |

Treatments indicated in **bold** had the top observed performance in a particular column.
* Treatments indicated with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.
NS – No significant difference was determined between treatments.

There was no significant difference in the reduction of mustard, annual grass or broadleaf weeds in the study. Tineweeding reduced weeds on average between 42.4 and 55.8% (Table 4). Annual grasses identified included foxtails (*Setaria* spp.), crabgrass (*Digitaria* spp.), barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.), and witchgrass (*Panicum capillary* L.). Annual broadleaf plants identified in the trial included redroot pigweed (*Amaranthus retroflexus* L.; Figure 2), common lambsquarters (*Chenopodium album* L.), common ragweed (*Ambrosia artemisiifolia* L.), three-seeded mercury (*Acalypha virginica* L.), and Pennsylvania smartweed (*Polygonum pensylvanicum* L.).

The timing of post-emergence tineweeding did have a significant difference on wheat mortality and the effectiveness of weed control (Table 5). The average wheat mortality was significantly lowest when tineweeding occurred 22 DAP. Tineweeding 11 DAP removed more mustard and annual grass weeds than the 22 DAP tineweed event. There was no significant difference in the reduction of annual broadleaf weeds by tineweed timing.

**Table 5. Effect of the timing of tineweed events on wheat mortality and weed reduction.**

| Tineweed timing | Wheat mortality | Mustard weed reduction | Annual grass weed reduction | Annual broadleaf weed reduction |
|---|---|---|---|---|
| | # plants | % | % | % |
| 5-May (11 DAP) | 4.2 | **68.1** | **69.9** | **64.0** |
| 3-June (22 DAP) | **0.0** | 16.6 | 33.1 | 47.6 |
| LSD (0.10) | 2.3 | 10.6 | 14.3 | NS |
| Trial Mean | 2.1 | 42.4 | 51.5 | 55.8 |

Treatments indicated in **bold** had the top observed performance in a particular column.
NS – No significant difference was determined between treatments.

**Table 6. Impact of weed control strategy on spring wheat yield and quality, 2011.**

| Treatment | Mustard yield | Wheat yield at 13% moisture | Crude protein at 12% moisture | Falling number | DON |
|---|---|---|---|---|---|
| | lbs/acre | lbs/acre | % | seconds | ppm |
| Standard | 183 | 454 | 13.9 | 397 | 0.30* |
| Standard + | 296 | 315 | **15.3** | 399 | 0.33 |
| Standard HD + | 227 | 594* | 14.1 | 391 | 0.43 |
| Standard 2/3 & Broadcast 1/3 + | 296 | 539 | 15.0 | 401 | 0.28* |
| Narrow HD + | 392 | **874*** | 14.3 | 402 | **0.18*** |
| Wide + | **148** | 838* | 14.4 | **417** | 0.20* |
| LSD (0.10) | NS | 282 | NS | NS | 0.13 |
| Trial Mean | 257 | 602 | 14.5 | 401 | 0.28 |

Treatments indicated in **bold** had the top observed performance in a particular column.
* Treatments indicated with an asterisk did not perform significantly lower than the top-performing treatment in a particular column.
NS – No significant difference was determined between treatments.

The treatment with the lowest mustard yield was "Wide +", with 9" row spacing, (148 lbs per acre), though this was not statistically lower than any of the other five treatments (Table 6; Fig. 5). There was a statistical difference in wheat yields across treatments, with the highest yield generated with "Narrow HD +", with 4.5" row spacing and an elevated seeding rate. This was not significantly higher than the wheat yields of "Wide +" or "Standard HD +".

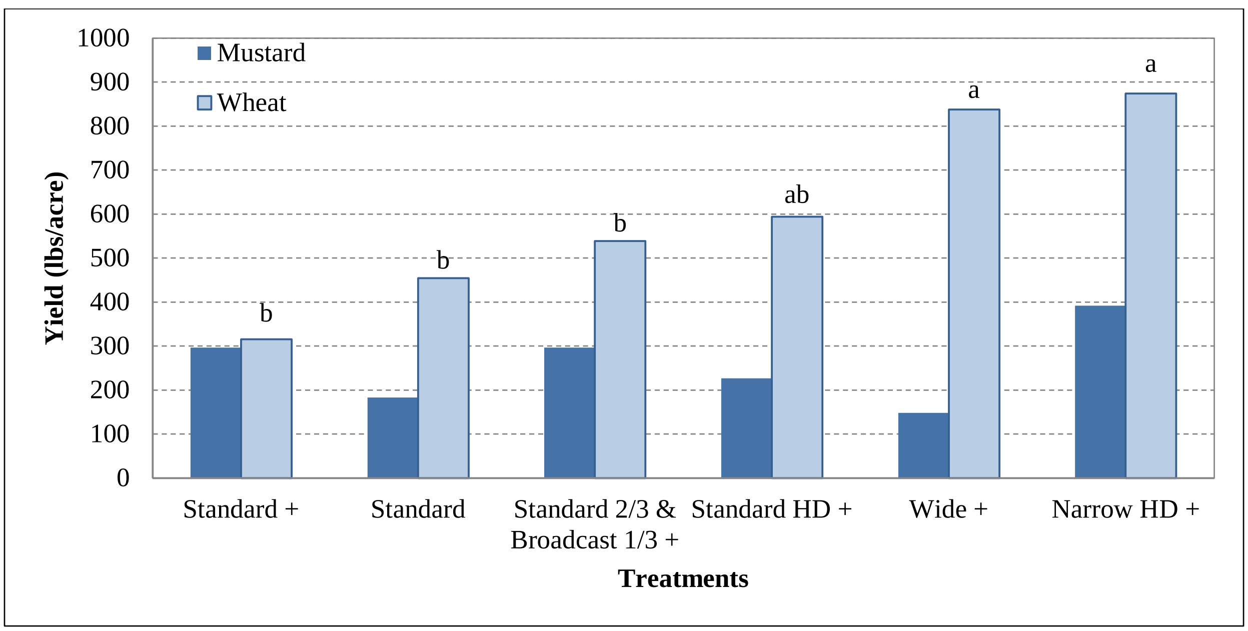


**Figure 5. Impact of weed control strategies on mustard and wheat yields. Treatments with the same letter did not differ in wheat yield (p=0.10). There was no significant difference in mustard yield by treatment.**

There were few wheat quality differences observed among treatments in this study. There was no significant difference in wheat crude protein concentration by treatment, and the average crude protein level was 14.5%. Falling numbers were not statistically different by treatment, and all treatments met industry standards. There was a significant difference in the levels of DON among the treatments (Table 6; Fig. 6). While all DON levels were within the standards for safe human consumption (the trial average was 0.28 ppm), the lowest DON level was in the "Narrow HD +" treatment (0.18 ppm). This was not significantly lower than "Wide +", "Standard 2/3 & Broadcast 1/3 +", or "Standard" treatments.

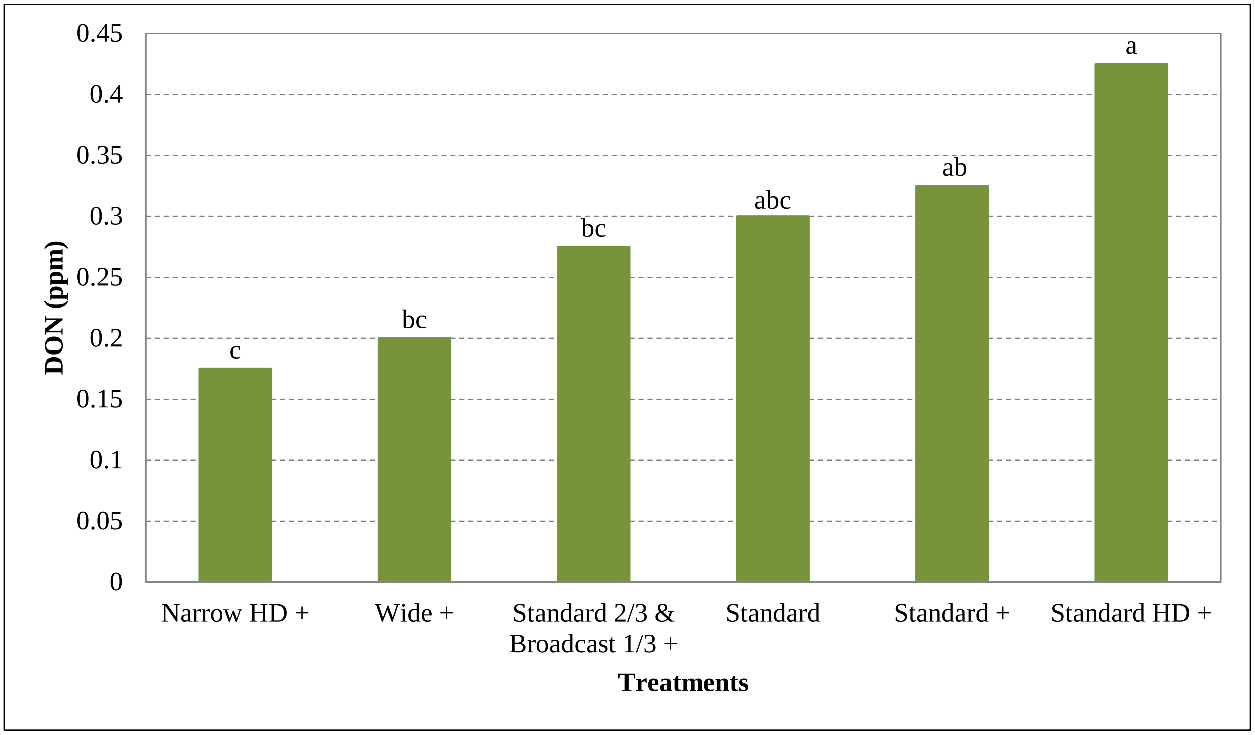


**Figure 6. The effect of weed control strategies on deoxynivalenol (DON) levels in harvested wheat. Treatments with the same letter did not differ in DON (p=0.10).**

# DISCUSSION

None of the treatments varied significantly in the reduction of mustard or annual weeds after tineweeding events. However, tineweeding did reduced weeds by 50%. As shown by other studies, the timing of tineweeding events can have a significant impact on the effectiveness of weed control. The first tineweeding event (11 DAP) caused a significantly greater reduction in mustard plants and annual grasses than the second event (22 DAP). The first tineweeding event most likely had weed seedlings that were not as well established as at the time of 22 DAP. Reduction of broadleaf weeds did not differ by tineweeding timing. This may be because cultivation with a tineweeder is still quite effective among annual broadleaf plants once they have established themselves a bit more strongly, though the difficulty of removing mustards and annual grasses increases greatly as roots establish. The average wheat mortality rate was significantly higher in the first tineweeding event (11 DAP), likely because the young wheat plants hadn't yet become firmly rooted in the ground. These results highlight the importance of tineweeding soon after emergence; so that weeds are eliminated in their “white thread root” stage and wheat can become more established early in the season.

Overall the spring wheat yields of this trial were very poor compared to past years. The trial yield average was 602 lbs per $ac^{-1}$ approximately 40% of normal yields. This was likely due to the poor weather conditions of this growing season resulting in a late planting, but the overall low yield was also due to the interseeded mustard, which caused heavy weed competition, as expected. Wheat yields were significantly different among weed control treatments, and were highest in “Narrow HD +”, “Wide”, and “Standard HD +”. These treatments all involved tineweeding as well as modification to row spacing and/or seeding rate. Interestingly, the “Standard +” treatment with tineweeding yielded the lowest. This low yield may be attributed to plant mortality from the tineweeding. Increasing the density and tineweeding improved overall yields and most likely weed control. Ultimately, it appears that several strategies will lead to improved weed control over just standard practices with or without tineweeding.

Each treatment yielded wheat with statistically similar crude protein levels and falling numbers. Crude protein, which should ideally be between 14-15%, was an average 14.5% for the trial. Falling numbers for each treatment were above 350 seconds, indicating low sprouting damage and good quality wheat. Deoxynivalenol (DON) levels, while significantly different, were all below the 1.0 ppm limit for human consumption. It is unclear what may have caused the significant difference in DON among treatments. High weed density may have created poor airflow through the wheat plots and resulted in an elevated DON level. This indicates that regardless of weed control treatment, this trial yielded wheat that was safe and of good quality.

While this study represents only one season of research, it implies that weed pressure is reduced by tineweeding and inter-row cultivation, that a variety of agronomic practices may comparably reduce weed competition, and that yield and quality does not need to be compromised in order to control weeds in organic spring wheat production.

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