2009 Tineweeding Trials

Figure 1. Early season crop tineweeding.

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2009 VERMONT TINEWEEDING TRIALS

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In 2009, the University of Vermont Extension Crops and Soils Team conducted an evaluation of tineweeding as a weed management strategy in corn, sunflowers, and canola in Alburgh, VT. Tineweeding is a type of mechanical cultivation that is implemented early on in the field season (Figure 1). A tineweeder is a low cost and simple piece of equipment designed to disturb the root zones of weed seedlings while they are in the very delicate "white thread root" stage (Figure 2). This disturbance often results in weed seedling desiccation and death.

Figure 2. White thread root stage of growth.

Weather Data

Seasonal precipitation and temperatures recorded at a weather station in close proximity to the 2009 research site is shown in Table 1. This growing season brought cooler temperatures and higher than normal rainfall resulting in fewer Growing Degree Days (GDD) than usual. Excess moisture and low soil temperatures resulted in poor germination, loss of plant available nutrients, and a slowed whole plant crop dry down rate. GDDs are reported for corn (base 50˚F), sunflowers (base 44˚F), and canola (base 41˚F) in Table 1.

Table 1.Temperature, precipitation, and GDD summary – 2009.

	May	June	July	August	September	October
Average Temperature	53.9	62.8	65.9	67.7	57.7	44.1
Departure from Normal	-2.7	-3.0	-5.2	-1.3	-2.7	-4.7
Precipitation	6.32	5.19	8.07	3.59	4.01	5.18
Departure from Normal	+3.39	+1.98	+4.66	-0.26	+0.55	+0.79
Corn (Base 50˚–86˚F)						
Growing Degree Days	209.0	398.0	494.5	557	286	40.5
Departure from Normal	-51.4	-76.0	-158.1	-32.0	-26.0	-61.8
Sunflowers (Base 44˚F)						
Growing Degree Days	325.5	565.5	657.5	708.5	428	113
Departure from Normal	-65.1	-88.5	-181.1	-66.5	-64.0	-82.3
Canola (Base 41˚F)						
Growing Degree Days	415.5	654	773.5	826.5	507.5	178.5
Departure from Normal	-68.1	-90.0	-159.0	-41.5	-74.5	-63.3

Based on National Weather Service data from South Hero, VT. Historical averages are for 30 years of data (1971-2000).

The effectiveness of a tineweeder as a weed control tool in three crops was evaluated with replicated plots at Borderview Farm in Alburgh, VT. The soil type was a silt loam and the previous crop was corn. The experimental design was a randomized complete block with three replications for each crop. All plots were planted on May 19, 2009. Five weed control strategies were tested: tineweeding 6 days after planting (DAP), tineweeding 12 DAP, tineweeding 6 and 12 DAP, herbicide, and no weed control. The seedbed was prepared with a moldboard plow, disked, and then finished with a spike tooth harrow.

Corn

Plots were seeded with a John Deere 1750 four row corn planter with the variety TMF2N422 (Mycogen) at 32,000 seeds/acre in 30 inch rows. A starter fertilizer (10-20-20) was applied at a rate of 250 lbs/acre. The plot size was 10’ x 30’. On May 29th Lumax (S-metolachlor, atrazine, and mesotrione) was sprayed on the plots that had an herbicide treatment at 2 qts/acre. Weed and crop populations were measured at 6 and 12 DAP, and again 5 weeks after planting. Weed identification was performed at each interval. On July 2nd, 61 lbs N/acre were sidedressed. The two center rows of each plot were harvested with a John Deere two row corn chopper on October

2nd. Yield was measured by weighing the forage wagon on drive-up platform scales. A subsample of corn was taken and analyzed for forage quality. Plot samples were dried, ground, and analyzed for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and 30 hour digestible NDF (dNDF). All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate treatment means when the F-test was significant (P< 0.10).

Table 2. Impact of weed control on corn.

Treatment	Height 5 weeks AP	Population	DM at harvest	Yield 35% DM	Weed biomass
	inches	plants/acre	%	tons/acre	lbs/acre
6 Day	14.0	27700	36.7	18.3	4840
12 Day	14.0	27200	36.0	19.3	4600
6 & 12 Day	12.7	**30000**	38.3*	21.7	2860
Control	**14.3**	27400	36.1	15.4	4470
Herbicide	13.0	**30000**	**40.1***	**27.0**	**0**
LSD (0.10)	NS	2220	1.77	NS	1940
Mean	13.6	28500	37.4	20.4	3350

* Treatments that did not perform significantly lower than the top performing treatment in a particular column are indicated with an asterisk.
NS - None of the treatments were significantly different from one another.

At 6 DAP, corn had not emerged, and was not affected by tineweeding. Very few weeds were present at that time, and those that were present were in the white thread stage. At 12 DAP, corn was still germinating or in the spike stage. There were very few corn casualties, and while some spikes were covered up as a result of the tineweeding, when height was measured at 5 weeks after planting, no significance was determined between treatments, demonstrating that tineweeding, and any associated disturbance the crop received in the rooting zone, did not retard plant growth. Mustards (*Brassica* spp.), foxtails (*Setaria* spp.), and redroot pigweed (*Amaranthus retroflexus L.*) were all eradicated by tineweeding measures. At harvest, common lambsquarters (*Chenopodium album* L.), yellow woodsorrel (*Oxalis stricta* L.), foxtails (*Setaria* spp.), Eastern black nightshade (*Solanum ptycanthum* Dun.), crabgrass (*Digitaria sanguinalis* L.), campion (*Silene* spp.), dandelion (*Taraxacum officinale* Weber), broad-leaved plantain (*Plantago major* L.), curled dock (*Rumex crispus* L.), buttercup (*Ranunculus repens* L.), and common ragweed (*Ambrosia artemisiifolia* L.) were found in both tineweeding treatments and in the control. However, while the control, 6 DAP tineweeding, and 12 DAP tineweeding treatments all had significantly more weeds than the herbicide plot and the double tineweeded treatment, it was not to the level where yield was affected, as there was no significance determined between yields and treatments at the 0.10 level.

Table 3. Impact of weed control on corn forage quality.

Treatment	Forage Quality Characteristics					Milk per	
	CP	ADF	NDF	dNDF	Nel		
	%	%	%	%	Mcal	ton	acre
6 Day	**7.13**	27.3	44.7	56.3	0.743	2830	18100
12 Day	7.10	28.1	46.4	57.0	0.737	2820	19200
6 & 12 Day	6.33	**28.2**	46.4	58.3	0.740	2870	21800
Control	6.80	26.8	44.0	**58.6**	0.750	2920	15900
Herbicide	6.97	**25.5**	**41.5**	58.3	**0.757**	**2970**	**28100**
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS
Mean	6.87	27.2	44.6	57.7	0.745	2880	20600

NS - None of the treatments were significantly different from one another.

No significance was determined between treatments and yield, CP, ADF, NDF, dNDF, Nel, and milk per ton or acre.

Weed biomass was significantly impacted by control strategies. Weed biomass was least in herbicide control plots. The next best control method was a two-time tineweeding. Single tineweeding events had weed biomass similar to no weed control (Figure 3).

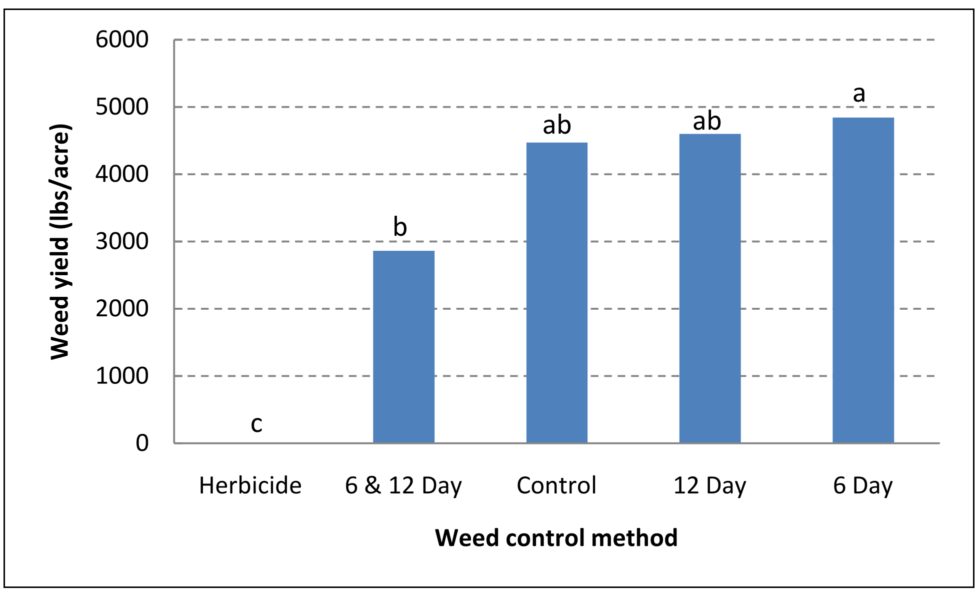

Figure 3. Effect of weed control on weed yield in pounds per acre in corn.

Treatment also had an effect on stand. Corn populations were greatest in the plots where weeds had been controlled with herbicide and with the 6 & 12 DAP tineweeding (Figure 4), which is slightly contrary to what one would expect. This suggests that there are other factors in play here, such as weed pressure resulting in lower populations. Regardless, as mentioned previously, weed control methods did not have any significant effect on yields.

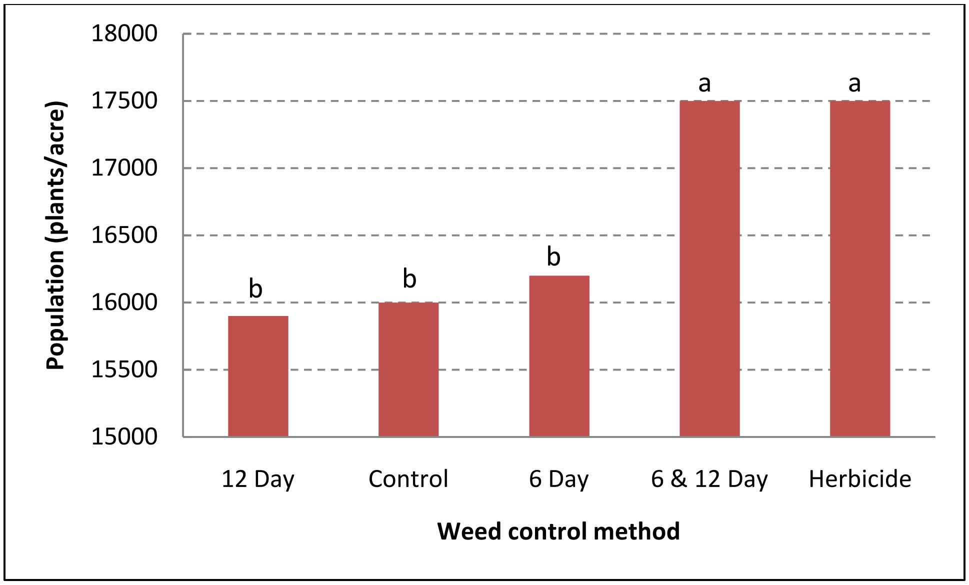

Figure 3. Effect of weed control method on corn population.

Weed control method had an effect on percent dry matter at harvest (Figure 5). Herbicide treatment resulted in the highest percent DM at harvest, coming off the field at 40%. This affect is well documented in scientific literature where a weed-free field results in faster whole plant dry down rates. Higher weed biomass resulted in slower corn dry-down.

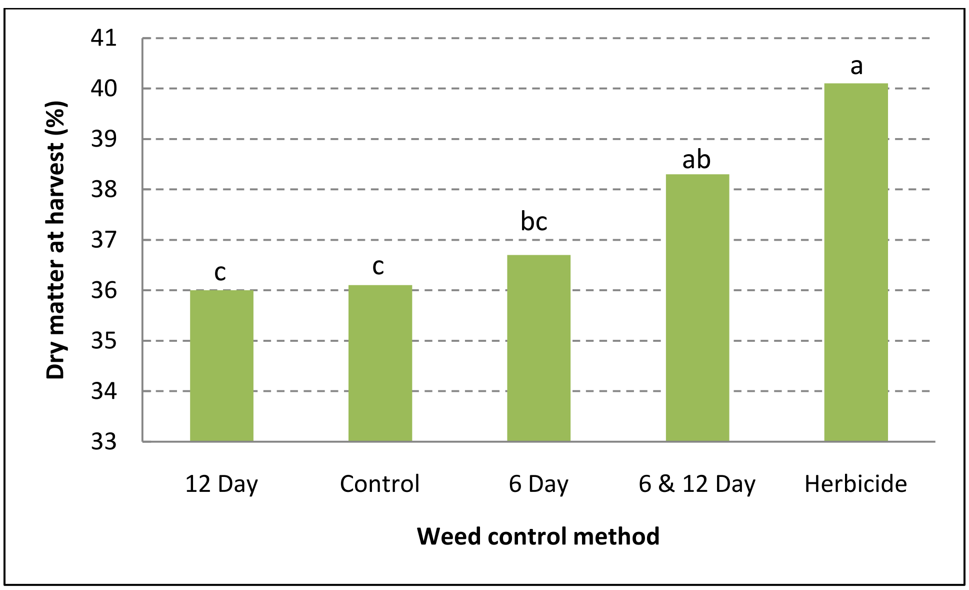

Figure 4. Effect of weed control on percent dry matter of silage corn at harvest.

The herbicide weed control treatment tended to be higher in yield than other treatments. The 6 & 12 DAP tineweeding treatment was very effective at controlling weeds. From the one season of data, it appears that the tineweeder can be an extremely effective weed control tool in corn.

Sunflowers

Plots were seeded with a John Deere 1750 corn planter equipped with sunflower fingers and the variety Hysun 521 (Interstate Seed) at a rate of 31,000 seeds per acre, with 30 inch spacing between rows. The plots size was 10' x 30'. Starter fertilizer (10-20-20) was applied at a rate of 250 lbs/acre. An additional 61 lbs of N were topdressed in early July. The sunflower plots were impacted by white mold (*Sclerotinia sclerotium*) a fungi that can be devastating to sunflower fields. White mold prevalence was primarily due to weather conditions (Figure 6).

Poast (sethoxydim) was applied on the herbicide plots at 2 pints per acre plus 2 pints of crop oil. Weed and crop populations were measured at 6 and 12 DAP, and again 5 weeks after planting. Weed identification was performed at each interval. Height was measured at 5 weeks after planting. In early September, sunflower height, head width, population, seed size, percent bird damage, and weed subsamples were collected. By September 4, 2009, bird damage was already extensive, and by the time the sunflowers had dried down enough to be harvestable, they were completely decimated. North Dakota State University Extension has developed a formula for inferring yields from seed size, population, head width, and seed set which has allowed us to make a conjecture on yield results from data collected. Percent survival was calculated by dividing the "harvest" population by the seeding rate. All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate treatment means when the F-test was significant (P< 0.10). No significance was found between tineweeding treatments and height as of 5 weeks after plant, harvest population, percent survival, height, head width, seed size, bird damage, calculated yield, or weed biomass (Table 4).

Figure 5. White mold resulting in shredded head skeleton. Note black sclerotia in the sunflower head. These black rock-like structures are the over-wintering structure of the fungi. These sclerotia will germinate in the spring and release spores.

At 6 DAP, sunflowers had not emerged, and so were not affected by tineweeding. Very few weeds were present at that time, and those that were present were in white thread stage. At 12 DAP, sunflowers were still germinating or at the cotyledon stage. Some seedlings were pulled out by the tineweeding, and some were covered up. Height taken 5 weeks after planting showed no significance between treatments, demonstrating that tineweeding, and any associated disturbance the crop received in the rooting zone, did not retard plant growth. By harvest, all tineweeded stands had recovered to such an extent that those few that were buried or uprooted caused no significant difference in percent survival compared with the control or the herbicide plot. Foxtail (*Setaria* spp.), redroot pigweed (*Amaranthus retroflexus* L.), and common lambsquarters (*Chenopodium album* L.) were all removed by the 12 DAP tineweeding treatment.

At harvest, common lambsquarters (*Chenopodium album* L.), yellow woodsorrel (*Oxalis stricta* L.), foxtails (*Setaria* spp.), crabgrass (*Digitaria sanguinalis* L.), campion (*Silene* spp.), common milkweed (*Asclepias syriaca* L.), morning glory (*Ipomoea* spp.), wild buckwheat (*Polygonum convolvulus* L.), common chickweed (*Stellaria media* L.), white clover (*Trifolium repens* L.), broad-leaved plantain (*Plantago major* L.), buttercup (*Ranunculus repens* L.), and redroot pigweed (*A. retroflexus)* were found in the tineweeding treatments and in the control, but not to the level where significance was determined between yields and treatments at the 0.10 level.

Table 4. Impact of weed control strategies on sunflower characteristics.

Treatment	Height, 5 weeks AP	Harvest population	Survival	Height	Head width	Bird damage	Sunflower yield		Weed biomass
	in	plants/acre	%	in	in	%	lbs/acre	bu/acre	lbs/acre
6 Day	10.0	20700	66.9	63.2	7.60	73.6	2176	77.7	1133
12 Day	**11.3**	20400	65.9	65.5	7.53	69.1	2108	75.3	1218
6 & 12 Day	11.0	18800	60.5	65.6	**7.83**	79.4	2075	74.1	505
Control	10.7	21900	70.7	64.6	7.33	54.1	2170	77.5	**1821**
Herbicide	10.2	**22900**	**73.9**	**67.9**	7.70	**79.6**	**2482**	**88.6**	594
LSD (0.10)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Means	10.6	20900	67.6	65.4	7.60	71.2	2200	78.6	1050

NS - None of the treatments were significantly different from one another.

There were no significant differences among weed control methods. However, there were several trends observed in the data. The herbicide weed control treatment tended to be higher in yield than other treatments. The 6 & 12 DAP tineweeding treatment was very effective at controlling weeds. From the one season of data, it appears that the tineweeder can be an extremely effective weed control tool in a sunflower crop. However, the tineweeder will cause some plant loss. If a farmer adopts this tool, he or she might consider planting at a higher seeding rate to compensate for plant losses.

Canola

Plots were seeded with a John Deere 750 grain drill and the variety Nex845CL (Mycogen) at 12 lbs/acre, with 7 inches between rows. The plots size was 10’ x 30’. Prior to planting, a total of 100 lbs N, 40 lbs P, and 40 lbs K fertilizer were broadcast applied and incorporated. Poast (sethoxydim) was sprayed on the plots that had an herbicide treatment at 2 pints per acre plus 2 pints of crop oil. Weed and crop populations were measured at 6 and 12 DAP, and again 5 weeks after planting. Canola height was also measured at 5 weeks after planting to determine plant growth post weed control strategy implementation. The crop was harvested on September 5, 2009 with an Almaco SP50 plot combine. Seed yields were measured at the time of harvest. At harvest, bird damage was at an estimated 75%. It is presumed that the extensive bird damage in the trial was due to the proximity of the plots to the sunflower trials, which were particularly hard-hit by avian pests. Taking this into consideration, yields were recalculated. Canola seeds from each plot were then extruded with a Kern Kraft Oil Press KK40, and oil yielded recorded. All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate treatment means when the F-test was significant ($P< 0.10$).

At 6 DAP, canola had emerged in some plots, but not all. Very few weeds were present at that time, and those that were present were in white thread stage. At 12 DAP, canola was in the cotyledon stage. Some seedlings were pulled out by the tineweeding, and many were covered up, but by harvest, the crop seemed to have recovered as there was no significant affect on yield (Table 5). Foxtail (*Setaria* spp.), redroot pigweed (*Amaranthus retroflexus* L.), and common lambsquarters (*Chenopodium album* L.) were all completely removed by 12 DAP tineweeding. There were few weeds present at 5 weeks after planting, most likely due to canola's quick tendency to form canopy closure. Height was also measured at 5 weeks after planting, and no significant difference between treatments was determined, demonstrating crop recovery after the disturbance of tineweeding. No significance was found between tineweeding treatments and seed and oil yield (Table 5). The percent oil is fairly low for this canola trial, as around 40-42% oil is expected for canola, depending on growing conditions, variety, and efficiency of your press. Our low oil percentage is most likely due to the canola seeds being very dry (~2% moisture) when attempting to press them in combination with the malfunction of the KK40 at time of pressing. The control, with no weed management strategy was the highest yielding out of all the treatments, but not statistically different from other weed control methods. All tineweeded plots recovered from observed damage, showing no significant difference in yield. Based on the data it appears that tineweeding may provide an acceptable method of weed control in canola fields. However, overall if early season weeds are controlled the quick canopy closure of canola can keep weed populations down throughout the growing season.

Table 5. Impact of weed control on canola characteristics.

Treatment	Height, 5 weeks AP	Yield		Oil		
	in	lbs/ac	bu/ac	lbs/ac	gal/ac	%
6 Day	**14.0**	1880	37.6	**149**	**19.5**	**34.0**
12 Day	12.8	1620	32.4	114	14.9	30.3
6 & 12 Day	13.0	1520	30.4	113	14.9	32.5
Control	**14.0**	**2050**	**41.0**	**149**	**19.5**	32.7
Herbicide	12.0	1430	28.6	111	14.5	33.5
LSD (0.10)	NS	NS	NS	NS	NS	NS
Means	13.2	1700	34.0	127	16.7	32.6

NS - None of the treatments were significantly different from one another.

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