Collaborative Project Summary: 2006-2007

Oil Seed Sunflowers for On-Farm Biodiesel Processing

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Project Description & Objectives.

This project was initiated to assess the agronomic and economic feasibility of sunflower to produce oil for on-farm biodiesel production. We were also interested in value-added by-products (e.g. high-protein animal feed) that could be used in an integrated farming operation. Sunflower was chosen as a research crop because of its high oil content, potential success for organic cultivation, and adaptability to equipment used for growing corn. When we began, very little work had been done looking at sunflower production in the Northeast. **Our objectives were: 1)** to gain familiarity with constraints and limitations of growing oilseed sunflowers in New England, **2)** to evaluate agronomic performance and yields of several sunflower varieties, and **3)** to evaluate oil yields and quality of meal produced from the seeds.

Report Outline

A. Sunflower variety trials, 2006 and 2007
   - Details and methodology
   - Seed yields

B. Sunflower oil/meal
   - Oil yields
   - Forage quality of meal

C. Undersowing for weed suppression and to provide winter groundcover
D. Conclusions and needs for future work
E. References

A. Sunflower variety trials, 2006 and 2007

Small replicated trials of several sunflower varieties were grown at UNH Kingman Farm (Madbury, NH). After harvest, oilseeds were pressed at Tuckaway Farm (Lee, NH).

Plant	Harvest	Summary	Plot Size
5/19/06	10/30/06	Variety trial, 5 varieties, 2 reps – *Kingman Farm* Harvested seeds, Pressed seeds for oil & meal	400’ x 6 rows
6/9/06	n/a	Variety trial, 5 varieties, 2 reps – *Kingman Farm* Not harvested – high weed pressure	400’ x 6 rows
5/8/07	11/15/07	Variety trial, 7 varieties, 3 reps – *Kingman Farm* Harvested seeds	170’ x 6 rows
5/17/07	n/a	Undersowing trial, 6 treatments, 3 reps – *Tuckaway Farm* Not harvested – high weed pressure	100’ x 4 rows
6/15/07	11/15/07	Undersowing trial, 6 treatments, 3 reps – *Woodman Farm* Harvested seeds	100’ x 4 rows

Fertility, Land preparation and Seeding: Amendments varied between experiments. At Kingman Farm, in 2006, 110 lbs/acre N (ammonium nitrate) 50 lbs/acre K_2O (muriate of potash) was broadcast and incorporated prior to planting, based on soil test recommendations. In 2007, liquid dairy manure was applied to provide 122 lbs/acre N, 65 lbs P_2O_5, and 98 lbs K_2O. For each variety, six rows were seeded using a two-row corn planter at 36" row spacing. Rows were seeded at 9" –12" between plants. In 2006, all seeds were commercially treated with both insecticides and fungicides. In 2007, three untreated varieties were included, including one organically produced variety.

Weed Control: No herbicides were used. In 2006, continuously wet ground kept us from cultivating. There was significant weed pressure, but the sunflowers outgrew the weeds (the predominant weed species was low-growing crabgrass). The degree to which competition reduced yields of this crop and the added seeds will reduce yields of future crops may have been significant. In 2007, timely cultivation kept weeds under control for most of the season. In a second field planting in 2006 which was not harvested, weeds outcompeted the sunflowers due to prior crop and weed control history.

Harvest: Timing of harvest was challenging in both years. It was important to wait until moisture content in the seeds is below 19%, and moisture content should be below 10% for storage. Seeds were not dry enough to harvest until mid-late September. An early frost would have sped up drying, but in both 2006 and 2007, we experienced very late fall frosts. The wet weather and mechanical troubles with the combine delayed harvest in both years. Once dry, the seeds are vulnerable to bird consumption. As a result, bird pressure was significant in both years. Although we did not estimate the percent loss due to birds, we observed more feeding in 2007 and some heads were entirely empty of seeds at harvest time. This may have been in part due to proximity to woods that provide shelter for birds.

For both years, yield data was obtained for the center two rows from 6-row plots, which totaled 1000-2400 square feet. These were extrapolated to per-acre rates shown in Tables 1 and 2 below. The amount of variation between varieties and between plots is evident in both Tables. It is important to note that we did not have enough replication or large enough plot sizes to get a highly accurate measure of yields. These should be considered estimates only.

In 2006, seeds were harvested using a John Deere 12A pull-behind platform head combine. Field loss was estimated to be as much as 20% by manually collecting heads that did not feed properly and combining them separately. Improvements to the combine head would reduce this loss. In 2007, a plot combine owned by the University of Vermont was used for harvesting. Although this machine was considerably slower than the John Deere combine, it was more thorough and field loss was minimal.

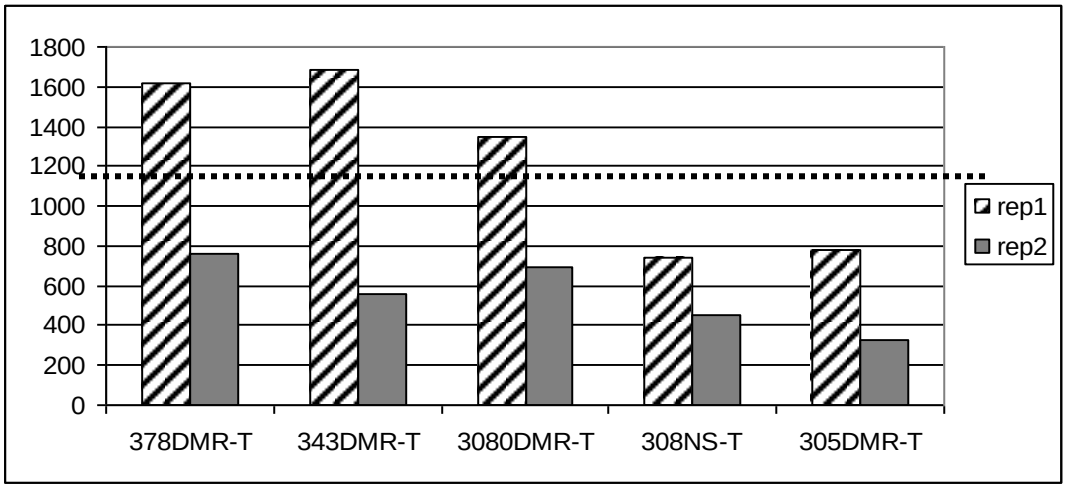

Table 1. Seed yields (lbs/acre) of 2 replicate plantings of five sunflower varieties in 2006, Kingman Farm, Madbury NH. 2006 U.S. average yields of 1,181 lbs/acre shown by dotted line.

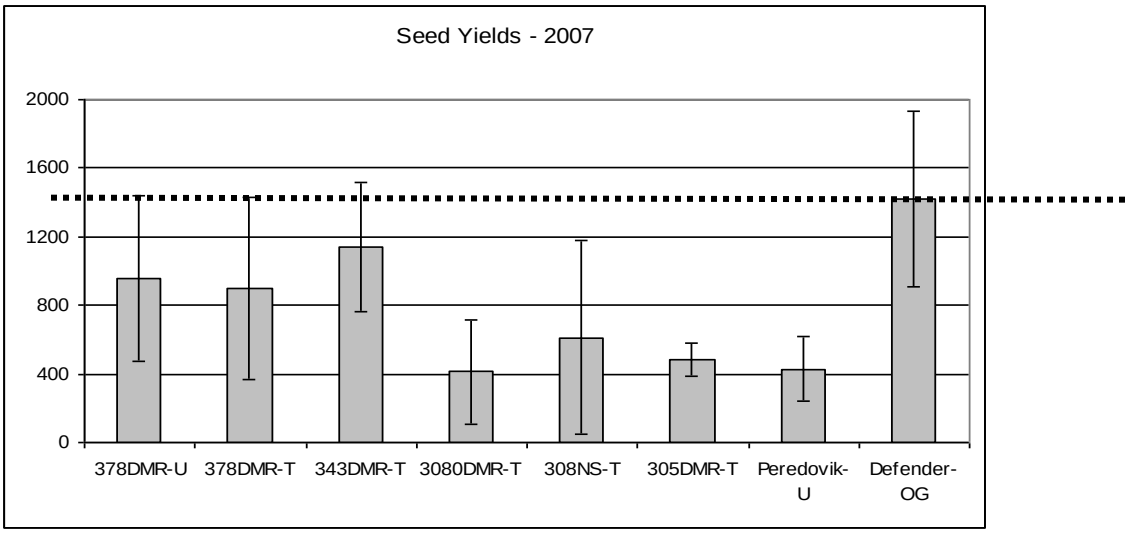

Table 1. Seed yields (lbs/acre) of 3 replicates of seven sunflower varieties in 2007, Kingman Farm, Madbury NH. Error bars show standard deviations around mean values. 2007 U.S. average yields of 1,454 lbs/acre shown by dotted line.

B. Sunflower oil and meal

In 2006, oil yields were determined by pressing a 10 lb sample from the combined plot harvests. Contact Dorn Cox for additional details on the press used. Oil yields were converted into gallons per 100 lbs of seed, and gallons/acre, assuming the higher yield values from the 2006 trial data.

			(based on high yields above)	
Variety	*ml oil/10 lb*	*gal/100 lb*	***gal/acre***	*oil %*
378DMR	1320	3.49	**56**	26%
343DMR	1660	4.39	**74**	33%
3080DMR	2120	5.60	**75**	42%
308NS	1760	4.65	**35**	35%
305DMR	1890	4.99	**39**	37%

Forage Quality of Sunflower Meal

Sunflower meal extracted from all five varieties was subjected to complete wet lab analysis at DairyOne forage analysis laboratory in Ithaca, NY. The meal stored well, showing no signs of becoming rancid after 12 months storage at room temperature. The sunflower meal was shown to be a high quality feed that could be a part of a balanced livestock ration. Component values for the five samples showed the following ranges:

% TDN (total digestible nutrients)	86-101
% Crude Fat	20.4-29.3
% Crude Protein	17.4-24.8
% Dry Matter	92.4-94.3

Copies of the forage analysis reports are available from Becky Grube, becky.grube@unh.edu.

Undersowing for weed suppression and to provide winter groundcover

In 2006, two significant problems with sunflower production were weed competition during the growing season and the inability to seed a winter cover crop after very late fall harvesting, leaving the soil bare and full of weed seeds for the next crop. In theory, both of these problems could be solved by seeding a winter cover crop underneath the established sunflowers that would simultaneously outcompete weeds and would then act as a cover crop during the fall and winter. Dorn applied for an was awarded a SARE farmer grant to study undersowing of different cover crops after the sunflower crop was established. A full report can be accessed by contacting either of the authors of this report. The preliminary results of these experiments are presented briefly here.

Undersowing treatments:
Bare cultivation (no undersowing)
Buckwheat – early (seeded 7/8, 3 lbs/1000 sq ft)
Winter Rye (seeded 7/8, 6 lbs/1000 sq ft)
Crimson Clover (seeded 7/8, 2/3 lbs/1000 sq ft)
Hairy Vetch (seeded 7/8, 1 lbs/1000 sq ft)
Buckwheat – late (seeded 7/25, 3 lbs/1000 sq ft)

Results:

In a field with lower weed pressure:

- Early buckwheat was the most effective at suppressing weeds during the hot summer months, as it germinated and established very quickly.
- Crimson clover and hairy vetch established slowly, but produced a thick mat of green vegetation by late November when sunflowers were harvested.
- Preliminary results suggest that there may be some yield reduction in plots where winter rye, clover or vetch was seeded, as compared with bare cultivated control.

In one field with very heavy ragweed pressure:

- None of the intercrop treatments were able to compete with the ragweed. The sunflowers were also unable to compete.

C. Conclusions and needs for future work

Our results show that it is possible to grow oilseed sunflowers in New England. In both years, we were able to obtain yields for at least one variety on par with the national average (1,181 lbs/acre in 2006 and 1,454 lbs/acre in 2007, USDA NASS). However, we saw tremendous variability in yields between plots (ranging from 400-1600 lbs per acre), in part because of challenges extrapolating small-plot yields to per-acre values. As a result, our data are not sufficient to provide realistic yield estimates in the Northeast. There is still a need for more detailed information about the fertility needs, optimum crop spacing, planting time, weed control, and harvesting strategies.

Based on our experiences, specific challenges to growing oilseed sunflowers for New England growers, particularly in organic production systems, are likely to include:

- Location, maintenance and operation of appropriately sized harvesting equipment
- Weed control (for organic systems)
- Lack of dry weather in the fall to permit sufficient drying prior to harvest.
- Bird or deer pressure

Problems that have been minimal or non-existent in our site but that might be more significant in other sites include Sclerotinia head rot, downy mildew, and other diseases. In particular, Sclerotinia has a very broad host range that includes many candidate rotation crops.

The use of intercrops for weed suppression and winter cover crop seem very promising based on the 2007 field trials. Additional work is needed to determine whether intercrop treatments decrease yields, the optimum timing for seeding, and the intercrops or combination of intercrops that are best suited to cultivation alongside sunflower.

E. References

Links to other oilseed crop studies in New England are maintained by Vern Grubinger, University of Vermont, at: http://www.uvm.edu/vtvegandberry/energylinks.html

Sunflower Production Guides:

Manitoba Guide to Sunflower Production and Management. July 2006. Manitoba Agriculture, Food and Rural Initiatives and the National Sunflower Association of Canada (NSAC). Available at http://www.ag.ndsu.edu/pubs/plantsci/rowcrops/eb25w-1.htm

Sunflower Production and Marketing. North Dakota State University Extension Bulletin No. EB25, rev. July 1995. Available at: http://www.ag.ndsu.edu/pubs/plantsci/rowcrops/eb25w-1.htm

High Plains Sunflower Production Handbook. Produced by Colorado State University, Kansas State University, University of Nebraska, University of Wyoming, and USDA ARS Central Great Plains Research Station. Kansas State University Bulletin MF-2384, June 2005. Available at: http://www.oznet.ksu.edu/library/crpsl2/MF2384.pdf

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