2019 Oilseed Meal Fertility Trial

Dr. Heather Darby, UVM Extension Agronomist
Rory Malone
UVM Extension Crops and Soils Technician
(802) 524-6501

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Dr. Heather Darby, University of Vermont Extension
heather.darby[at]uvm.edu

Oilseed meal can provide a source of plant-derived nitrogen fertilizers. Agronomic research is needed to help farmers implement these alternative fertility sources. Seed meals are a high-protein byproduct of seed oil extraction from crops such as soybean, canola, sunflower, hemp, and peanut. While a byproduct, seed meals still retain nutrient value after oil extraction, and are high in protein. Hence, seed meals are often utilized as livestock feed. Seeds meals can also be used as organic soil amendments, and can act as organic fertility sources to farmers. In order to examine the efficacy of several seed meals as fertilizers, the University of Vermont Extension Northwest Crop and Soils (NWCS) Program conducted a trial in the 2019 field season and evaluated sweet corn yield and soil nitrate-N (NO_3) levels.

MATERIALS AND METHODS

The trial was established at Borderview Research Farm in Alburgh, VT in the 2019 field season to assess the effectiveness of oilseed meals as fertility amendments in sweet corn (Table 1). The experimental design was a randomized complete block with four replicates. The previous crop was hemp and plot dimensions were 10’ x 20’. The soil type was Benson rocky silt loam with 8-15% slopes. Treatments included feed grade soybean meal (Blue Seal, Kent Nutrition Group, Muscatine, IA), cold pressed soybean meal obtained from the Borderview Research Farm (Alburgh, VT), peanut meal (LD Oliver Seed Company, Milton, VT), cold pressed hemp meal (Borderview Research Farm), cold pressed canola meal (Borderview Research Farm), nitrogen synthetic fertilizer (46-0-0), and an untreated control. To obtain oilseed meal from soybean, hemp, and canola, the seed were cleaned with a small Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN), and the oilseed was extruded with a KernKraft 40 cold-press oil mill.

Prior to planting the sweet corn, fertility treatments were broadcast by hand into the plots at a rate that would supply 100 lbs nitrogen ac^{-1} and incorporated with harrows on 31-May. Sweet corn (var ‘Sugar Buns’, 70 RM) was planted with a 1750 John Deere corn planter at 22,000 seeds ac^{-1} on 6-Jun.

Table 1. Agronomic information for the meal fertility trial, Alburgh, VT, 2019.

	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam 8-15% slopes
Previous crop	Hemp
Planting date	6-Jun
Plot size (feet)	10 x 20
Replicates	4
Sweet corn variety	Sugar Buns (F1, 70 days RM, treated)
Sweet corn seeding rate (seeds ac^{-1})	24,000
Fertilizer treatment application rate (lbs N ac^{-1})	100
Harvest date	20-Aug

The nutrient content of oilseed meals were determined at the Dairy One Forage Testing Laboratory (Ithaca, New York) on 14-May. The nitrogen (N), phosphorus (P), and potassium (K) values are displayed by treatment in Table 2. Soil samples were collected on 30-May before amendment application, at planting, then every two weeks until 10-Sep. Samples were analyzed for nitrate-N (NO_3-) at the University of Vermont's Agricultural and Environmental Testing Laboratory (Burlington, Vermont).

Table 2. Nitrogen, phosphorus, and potassium by treatment on a dry matter basis.

Treatment	N	P	K
	% dry matter		
Canola meal	4.81	1.09	1.21
Soybean meal- Borderview	7.12	0.68	1.95
Soybean meal- feed grade	8.33	0.74	2.18
Hemp meal	5.65	1.05	1.10
Peanut meal	8.71	0.85	1.24
Urea	46.0	0.00	0.00

Corn was harvested by hand on 20-Aug. Three stalk heights per plot were measured prior to harvest. Ears from the center two rows were collected and weighed in order to determine yield, and the length of five ears from each plot were measured to determine average ear length.

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p<0.10$.

Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these treatments were significantly different from one another. Treatment B was not significantly lower than the top yielding treatment, indicated in bold. A lack of significant difference is indicated by shared letters.

Treatment	Yield
A	6.0^{b}
B	7.5^{ab}
C	**9.0^{a}**
LSD	2.0

RESULTS

Weather data were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 3). The 2019 field season had below average temperatures and fewer Growing Degree Days (GDDs) in June and August.

Temperatures increased to 2.87° F above the 30-year normal in July, which also saw 1.81 inches below normal of precipitation. In August, temperature and precipitation were slightly below the normal. Overall, there were 1730 GDDs accumulated June through August, 34 above the average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2019.

Alburgh, VT	June	July	August
Average temperature (°F)	64.3	73.5	68.3
Departure from normal	-1.46	2.87	-0.51
Precipitation (inches)	3.06	2.34	3.50
Departure from normal	-0.63	-1.81	-0.41
Growing Degree Days (50°F-	446	716	568
Departure from normal	-29	76	-13

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

Sweet corn height and ear length did not statistically differ by treatment (Table 4). Sweet corn populations were highest in the plots fertilized with urea, which was significantly higher than the feed-grade soybean meal and peanut meal treatments. Corn yields were highest in the plots fertilized with urea at 14,484 lbs ac^{-1} or 7.24 tons ac^{-1}, which was statistically similar to the hemp, canola, and Borderview soybean meal amendments. The peanut meal yielded significantly lower than all other treatments, yielding 9344 lbs ac^{-1}, or 4.67 tons ac^{-1}. These differences in yield may be due to differences in N uptake efficiency in the different amendments, but yield is also influenced by differences in population. The average trial yield was 12,574 lbs ac^{-1} or 6.29 tons ac^{-1}.

Table 4. Seed meal fertility harvest results, Alburgh, VT, 2019.

Treatment	Population	Height	Yield		Ear length
	plants ac^{-1}	cm	lbs ac^{-1}	tons ac^{-1}	cm
Canola	23196^{ab}	160	13220^{ab}	6.61^{ab}	18.1
Hemp	23849^{a}	158	14005^{a}	7.00^{a}	19.0
Peanut	15028^{c}	160	9344^{c}	4.67^{c}	**19.1**
Soybean- Borderview	22107^{ab}	162	12720^{ab}	6.36^{ab}	19.1
Soybean- feed grade	20147^{b}	144	11674^{b}	5.84^{b}	18.6
Urea	**24394^{a}**	**167**	**14484^{a}**	**7.24^{a}**	18.7
LSD (0.10)	3543	NS	2195	1.10	NS
Trial Mean	21453	159	12574	6.29	18.7

[†]Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**
LSD – Least significant difference. NS- Not significant

By 17-Jun, the peanut and feed grade soybean meals and urea soil nitrate concentrations had reached 25ppm. By 1-Jul, all treatments had reached 25ppm, which is considered sufficient for producing high yielding sweet corn.

Soil nitrate concentrations statistically differed by treatment on the 10-Jun and 17-Jun sampling dates (Table 5; Figure 1). On 10-Jun, the peanut meal had the highest soil nitrate-N concentration, 20.2 mg N kg^{-1}, and was statistically similar to the urea and feed-grade soybean meal, which were 19.2 and 17.4 mg N kg^{-1} respectively. On 17-Jun, the feed-grade soybean meal was the top performer at 32.9 mg N kg^{-1}, and was similar to the peanut meal and urea (29.9, 26.6 mg N kg^{-1}). Urea was the top performer in nitrate-N concentrations from 15-Jul to 27-Aug, but was not significantly different from the other treatments. This indicates that the organic oilseed meal amendments are suitable as a substitute for fertilizers like urea. The feed-grade soybean meal hit its peak nitrate-N concentration first (75.6 mg N kg^{-1}), on 15-Jul, while all other amendments hit their peak nitrate-N levels on 30-Jul (Figure 1). While feed-grade soybean meal and peanut meal had the highest nitrate-N concentrations from 17-Jun to 1-Jul, they were surpassed by urea and hemp meal by 30-Jul, which peaked at 132 and 108 mg N kg^{-1} respectively. All treatments except urea and peanut meal had a second peak of nitrate-N on 27-Aug.

Table 5: Soil nitrate concentrations by treatment and date, Alburgh, VT, 2019.

Treatment	Nitrate (mg N kg^{-1})								
	30-May	10-Jun	17-Jun	1-Jul	15-Jul	30-Jul	13-Aug	27-Aug	10-Sep
Canola	6.47	10.7[b]	16.6[bcd]	26.5	48.3	75.9	40.2	45.7	16.8
Hemp	5.67	11.3[b]	12.3[cd]	39.0	58.7	108	67.8	75.8	**55.3**
Peanut	6.63	**20.2[a]**	29.9[ab]	53.8	68.0	82.3	56.8	47.7	26.2
Soybean- Borderview	6.24	9.90[b]	8.60[d]	**56.2**	63.6	78.6	60.7	65.1	25.3
Soybean- feed grade	6.59	17.4[a]	**32.9[a]**	52.1	75.6	73.2	55.2	57.0	29.5
Urea	**7.03**	19.2[a]	26.6[abc]	42.6	**103**	**132**	**85.0**	**76.7**	47.8
LSD (0.10)	NS	5.03	15.9	NS	NS	NS	NS	NS	NS
Sample date mean	6.44	14.8	21.2	45.0	69.5	91.7	61.0	61.3	33.5

†Treatments within a column with the same letter are statistically similar. Top performers are in **bold.**

LSD – Least significant difference.

NS- Not significant.

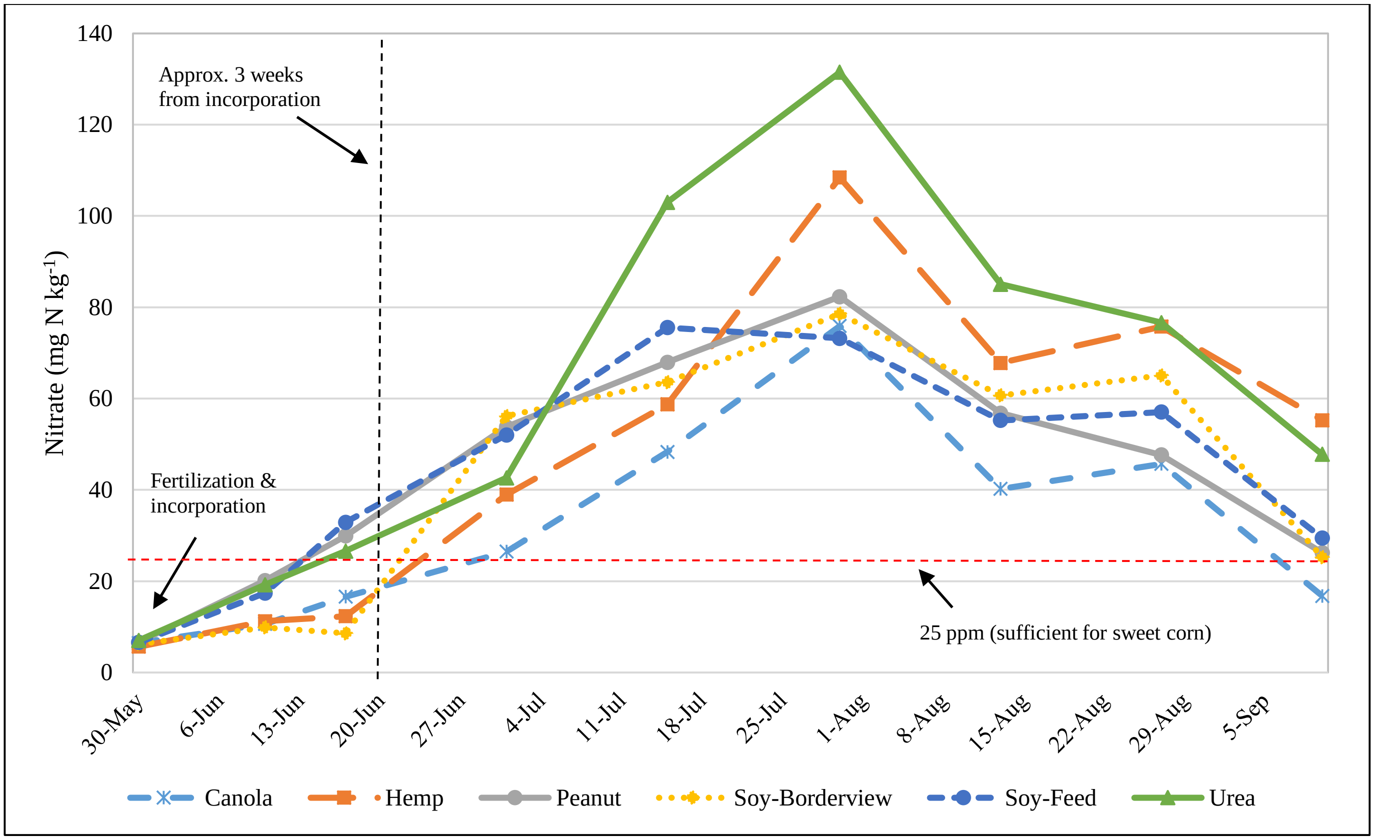

Figure 1: Soil nitrate-N concentrations from 30-May to 10-Sep, Alburgh, VT, 2019.

DISCUSSION

This study suggests that oilseeds meals have the potential to deliver adequate N to crops. After 1-Jul, all nitrate concentrations were above 25ppm, which is required at the critical uptake period of corn in order to meet the nitrogen demand of the crop for the season. Sweet corn was used as a test crop since it requires significant amounts of N to produce high yields. Early in the season, the urea and peanut meal mineralized more rapidly, and later in the season, while not statistically significant, hemp meal performed second to urea and provided an extended release over the field season. Hemp meal also was a top-performer along with urea in corn yield and population. Different organic amendments could be implemented for different nutrient timing goals based on how they mineralize. For example, you could apply multiple organic amendments, one with more early-season mineralization, and one with more late-season mineralization, to achieve the desired nitrate-N throughout the growing season.

These oilseed meal amendments generally have similar phosphorus concentrations to poultry manure, but higher nitrogen concentrations (Table 2). Poultry manure generally has N-P-Ks ranging from 3-2.5-1.5 to 6-4-3, and applying manures like poultry manure for nitrogen-based fertilization adds much more phosphorus than corn and vegetable systems can remove. Oilseed meal amendments could be used in place of poultry manures to provide adequate nitrogen for crops, while applying a lower phosphorus rate. Table 6 shows the pounds of each treatment applied to achieve a rate of 100 lbs N ac^{-1}, and the corresponding phosphorus and potassium rates applied. Out of the oilseed meals, the soybean meals resulted in the least amount of phosphorus applied, followed by the peanut meal.

Table 6. Application rates as applied and by nutrient, Alburgh, VT, 2019.

Treatment	Amendment	N	P	K
	lbs ac^{-1}			
Canola	2079	100	22.7	25.2
Soybean	1404	100	9.55	27.4
Feed Soy	1200	100	8.88	26.2
Hemp	1770	100	18.6	19.5
Peanut meal	1148	100	9.76	14.2
Urea	217	100	0.00	0.00

As a by-product of oil production, oilseed meals can be a cost-effective fertilizer for biodiesel operations, or growing oil industries like hemp oil. It is important to remember this trial only represents one season of data and further research is needed.

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