NORTHWEST CROPS & SOILS PROGRAM

2020 Oilseed Meal Fertility Trial

Dr. Heather Darby, UVM Extension Agronomist
Rory Malone, Ivy Luke, and Lindsey Ruhl
UVM Extension Crops and Soils Technicians
(802) 524-6501

Visit us on the web at: http://www.uvm.edu/nwcrops

THE UNIVERSITY OF VERMONT EXTENSION

2020 OILSEED MEAL FERTILITY TRIAL

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 2020 field season and evaluated sweet corn yield and soil nitrate-N (NO_3) levels following soil amendment with various oilseed meals.

MATERIALS AND METHODS

The trial was established at Borderview Research Farm in Alburgh, VT in the 2020 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 silage corn and plot dimensions were 10' x 20' and the soil type was Covington silty clay loam, with 0-3% slopes. Treatments included feed grade soybean meal (Blue Seal, Kent Nutrition Group, Muscatine, IA), cold pressed soybean meal from 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), urea (46-0-0), a split-application urea treatment, and an untreated control. To obtain oilseed meal from soybean, hemp, and canola, the seed were cleaned with a Clipper M2B cleaner (A.T. Ferrell, Bluffton, IN), and the oilseed was extruded with an AgOil M70 cold-press oil mill (Mondovi, WI).

Table 1. Agronomic information for the meal fertility trial, Alburgh, VT, 2020.

	Borderview Research Farm Alburgh, VT
Soil type	Covington silty clay loam, 0-3% slopes
Previous crop	Corn
Planting date	5-Jun
Plot size (feet)	10 x 20
Replicates	4
Sweet corn variety	Delectable (F1, 80-day RM)
Sweet corn seeding rate (seeds ac^{-1})	22,000
Fertilizer treatment application rate (lbs N ac^{-1})	100
Harvest date	20-Aug

Prior to planting the sweet corn, fertility treatments were broadcast by hand into the plots on 4-Jun at a rate that would supply 100 lbs nitrogen ac^{-1} based on the analysis, except for the split-application urea treatment, which was applied at a rate of 50 lbs nitrogen ac^{-1}. On 5-Jun, the amendments were incorporated with a tine weeder and sweet corn (var 'Delectable F1', 80 RM) was planted with a 1750 John Deere corn planter at a rate of 22,000 seeds ac^{-1}. On 7-Jul, a second application of urea was applied to the split application treatment plots to supply another rate of 50 lbs nitrogen ac^{-1}. The nutrient content of oilseed meals were determined at the Dairy One Forage Testing Laboratory (Ithaca, New York) on 26-May. The nitrogen (N), phosphorus (P), and potassium (K) values are displayed by treatment in Table 2. The sweet corn was sprayed with three quarts Lumax® herbicide to reduce grasses and broadleaf weeds on 25-Jun. Soil samples were collected on 19-May before amendment application, at planting, then every two weeks until 18-Sep. Samples were analyzed for nitrate-N (NO_3) at the University of Vermont's Agricultural and Environmental Testing Laboratory (Burlington, Vermont). Corn populations were counted by row prior to harvest. Corn was harvested by hand on 20-Aug from ten-foot sections of the center two rows, and the ears weighed in order to determine yield. The length of five ears and three ear diameters from each plot were measured.

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

Treatment	N	P	K
	% dry matter		
Canola meal	4.68	1.13	1.25
Soybean meal- Borderview	6.36	0.98	2.57
Soybean meal- feed grade	7.43	0.75	2.42
Hemp meal	5.08	1.27	1.05
Peanut meal	9.00	0.94	1.63
Urea	46	0	0

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 2020 field season saw increased Growing Degree Days (GDDs), especially in July, which had had 751 GDDs, 121 greater than the 30-year average. The summer had another record-setting July of high heat, with an average temperature of 74.8° F, 4.17° F above the normal. Temperatures were above average June-August, and precipitation was below average in June and July. Overall, 2187 GDDs accumulated June through August, 134 above the norm. There were 15.3 inches of precipitation during the growing season, 0.1 inches below the norm.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2020.

Alburgh, VT	June	July	August	September
Average temperature (°F)	66.9	74.8	68.8	59.2
Departure from normal	1.08	4.17	0.01	-1.33
Precipitation (inches)	1.86	3.94	6.77	2.75
Departure from normal	-1.77	-0.28	2.86	-0.91
Growing Degree Days (50° F)	516	751	584	336
Departure from normal	35	121	2	-24

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 yields, populations per acre, and ear lengths and widths did not statistically differ by treatment (Table 4). The average trial sweet corn yield was 11,364 lbs ac^{-1} (5.68 tons ac^{-1}). While ear lengths and widths were not statistically different by treatment, the split application of urea treatment had the largest corn dimensions, and it also had statistically greater soil nitrate levels at several dates. Soil nitrate concentrations are shown below in Table 5. By 12-Jun, all treatments had reached 25ppm, which is considered sufficient for producing high yielding sweet corn.

Table 4. Seed meal fertility harvest results, Alburgh, VT 2020.

Treatment	Population	Yield		Ear length	Ear width
	plants ac^{-1}	lbs ac^{-1}	tons ac^{-1}	cm	cm
Canola	8004	9845	4.92	33.1	6.54
Control	7841	12589	6.29	33.2	6.38
Hemp	8004	12807	6.40	33.8	6.75
Peanut	7786	11369	5.68	33.0	6.54
Soybean (feed-grade)	7786	11587	5.79	32.4	6.67
Soybean (Borderview)	8222	10411	5.21	33.7	6.83
Split application urea	7296	10759	5.38	35.5	7.08
Urea	6153	11543	5.77	34.0	6.33
LSD (0.10)†	NS‡	NS	NS	NS	NS
Trial Mean	7637	11364	5.68	33.6	6.64

†LSD- Least significant difference at the p=0.10 level.

‡NS- Not significant at the p=0.10 level.

Table 5: Soil nitrate concentrations by seed meal fertility treatment and date, Alburgh, VT 2020.

Treatment	Nitrate (mg N kg^{-1})							
	19-May	12-Jun	9-Jul	24-Jul	6-Aug	20-Aug	3-Sep	18-Sep
Canola	11.8	35.7	81.2	43.9	14.3[c†]	16.3[bc]	13.1	20.9[bc]
Control	12.6	43.6	60.8	32.0	10.1[c]	8.83[c]	8.75	18.6[c]
Hemp	13.8	39.9	99.7	49.3	21.7[abc]	17.8[bc]	14.0	22.5[bc]
Peanut	19.2	43.2	111	51.9	19.4[bc]	19.5[bc]	21.0	33.5[a]
Soybean (feed-grade)	12.0	37.1	73.0	48.7	31.2[ab]	19.4[bc]	15.7	28.7[ab]
Soybean (Borderview)	12.2	49.4	88.7	46.2	11.0[c]	14.1[c]	11.2	21.1[bc]
Split application urea	14.7	48.5	108	83.9	34.8[a]	35.7[a]	30.3	35.8[a]
Urea	12.9	49.5	108	42.0	29.9[ab]	26.5[ab]	12.7	27.8[abc]
LSD (0.10)‡	NS§	NS	NS	NS	15.2	10.7	NS	9.27
Sample date mean	13.7	43.3	91.3	49.7	21.6	19.7	15.8	26.1

†Treatments within a column with the same letter are statistically similar.

‡LSD – Least significant difference.

§NS- Not significant.

Soil nitrate concentrations statistically differed by treatment on the 6-Aug, 20-Aug, and 18-Sep sampling dates (Table 5, Figure 1). On all three dates the split application urea treatment had the highest soil nitrate levels, at 34.8, 35.7, and 35.8 mg N kg^{-1} respectively. On 6-Aug the hemp (21.7 mg N kg^{-1}) and feed-grade soybean meal (31.2 mg N kg^{-1}) were statistically similar to the split application urea, though the hemp was similar to the control (10.1 mg N kg^{-1}). On 20-Aug the urea (26.5 mg N kg^{-1}) was statistically similar to the split application urea, and on 18-Sep the peanut meal (33.5 mg N kg^{-1}), feed grade soybean meal (28.7 mg N kg^{-1}), and urea (27.8 mg N kg^{-1}) were similar, though the urea treatment was similar to the control (18.6 mg N kg^{-1}) as well. This indicates that the organic oilseed meal amendments can be suitable as a substitute for fertilizers like urea.

Early on the urea had the higher soil nitrate-N levels, at 49.5 mg N kg^{-1} on 12-Jun, then fell behind other treatments (See Figure 1). All treatments hit their nitrate-N concentration peak on 9-Jul, with peanut meal the highest at 111 mg N kg^{-1}, followed by urea (108 mg N kg^{-1}) and split application urea (108 mg N kg^{-1}). After 9-Jul, the split application urea treatment surpassed the other treatments for the rest of the season. Several treatments had a peak on 20-Aug instead of a consistent decline in nitrate-N concentrations from July to 20-Aug. These were: canola, peanut, Borderview soybean, and split application urea. These treatments show potential to provide a sustained release of nitrogen lasting later into the growing season.

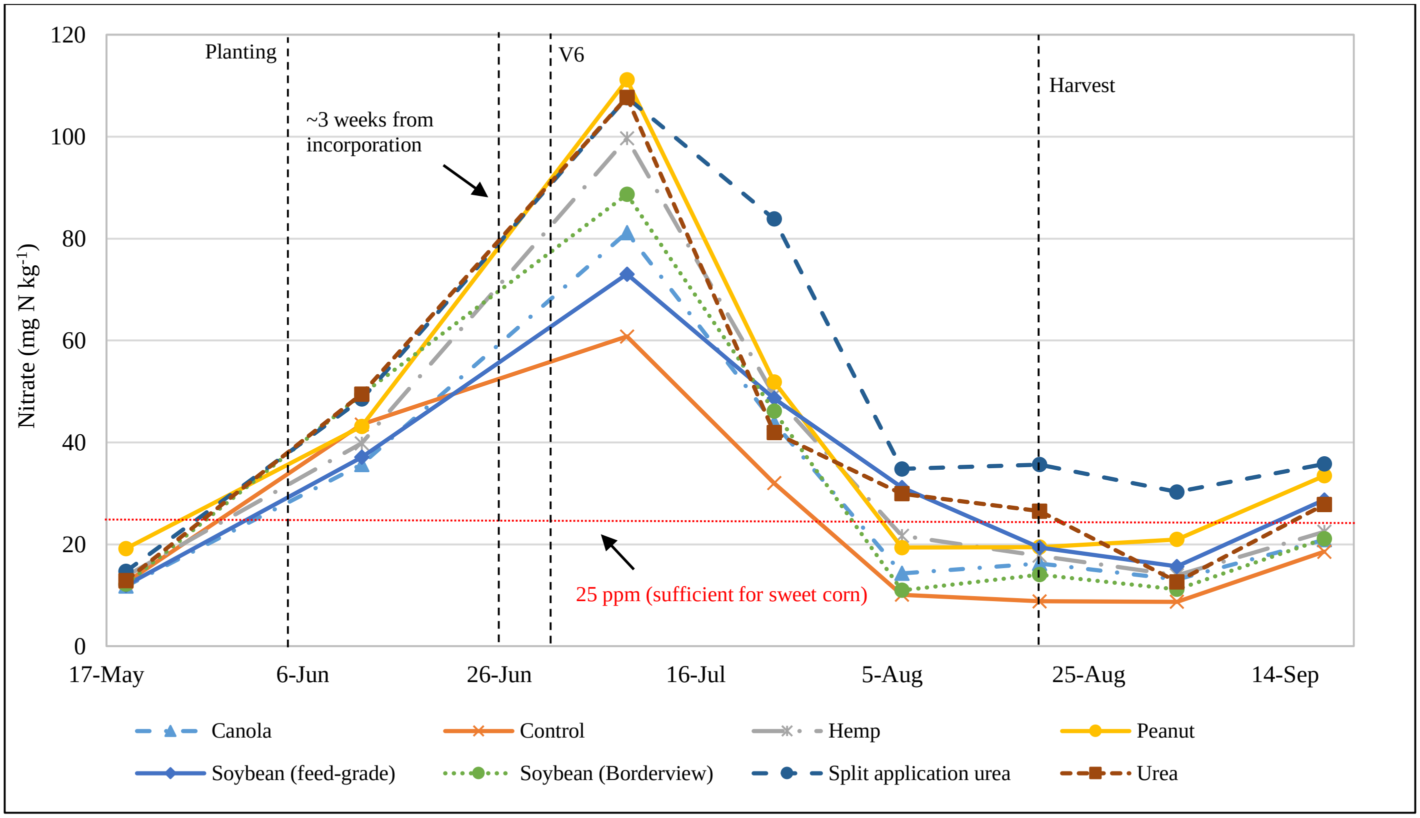

Figure 1: Soil nitrate-N concentrations from 19-May to 18-Sep, Alburgh, VT, 2020.

DISCUSSION

This study suggests that oilseeds meals have the potential to deliver adequate N to crops. After 12-Jun, 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. Mineralization rates may have been increased this year due to the hot and dry July. In comparison to previous years, this July had 121 GDDs above average, while 2018 and 2019 had 88 and 76 GDDs above average respectively. Nitrate concentrations were highest this year in hemp meal (99.7 mg N kg^{-1} instead of 80.4 and 108 in 2018 and 2019) and peanut meal (111 mg N kg^{-1} instead of 56.9 and 82.3), but not for urea (108 mg N kg^{-1} instead of 69.8 and 132). 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. This targeted approach can also help minimize excess nitrogen at the end of the season. Average end-of-the-season nitrate this year was lower than last year. Nitrate increased from 15.8 to 26.1 mg N kg^{-1} from 3-Sep to 18-Sep, while it was 33.5 mg N kg^{-1} on 10-Sep in 2019, which was fertilized at the same rate.

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 feed-grade soybean meal resulted in the least amount of phosphorus applied, followed by the peanut meal. Hemp and canola meal had the highest concentrations of phosphorus applied.

Table 6. Application rates as applied and by nutrient, Alburgh, VT, 2020.

Treatment	Application rate	N	P	K
	lbs ac^{-1}			
Soybean meal- Borderview	1572	100	15.4	40.4
Hemp meal	1969	100	25.0	20.7
Canola meal	2138	100	24.2	26.7
Soybean meal -feed grade	1346	100	10.1	32.6
Peanut meal	1111	100	10.4	18.1
Urea	217	100	0.0	0.0

As a byproduct 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.

ACKNOWLEDGEMENTS

The UVM Extension Northwest Crops and Soils Program would like to thank Roger Rainville and the staff at Borderview Research Farm for their generous help and hosting this trial as well as Henry Blair, John Bruce, Catherine Davidson, and Sara Ziegler for their assistance with data collection and entry. Any reference to commercial products, trade names, or brand names is for information only, and no endorsement or approval is intended.