SF713 (Revised 2022)

Fertilizing Sunflower

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Sunflower (*Helianthus annuus* L.) is a New World crop, domesticated in eastern North America about 4,000 years ago (Blackman et al., 2011). Perhaps due to the development of sunflower relatively recently in human history and its breeding as an oil seed for yield, the efficiency of nitrogen (N) utilization by sunflower is relatively high. Nitrogen application increases plant height but may or may not increase yield.

Oilseed sunflower is grown, as the name indicates, for oil content. Increasing the N rate increases seed protein and decreases oil concentration (Darby et al., 2013). Confection sunflower is grown for human consumption as a snack food. It is dehulled and the kernel is used on salads, and in SunButter™ and bakery goods. It is also incorporated into snack foods and other food recipes.

Nitrogen recommendations in North Dakota are now based on a yield-independent economic production function, while for most other states, including South Dakota, Nebraska and Kansas, N recommendations are based on expected-yield formulas. Formulas include reducing N recommendations due to soil test nitrate (Nebraska, South Dakota, North Dakota, Kansas), organic matter (Kansas, Nebraska) and all states by manure and previous crop credits. In contrast to the implied N response formula, which most often is constructed as [(Yield Expected (pounds per acre) multiplied by 0.05) less credits], recent N rate experiments in other states have achieved less yield response to N than expected (Darby et al., 2013; Scheiner et al., 2002).

This publication of North Dakota sunflower N recommendations is based on the results from 52 total experiments: four North Dakota N rate experiments in 2012-13, 40 North Dakota N and phosphorus (P) rate experiments in 2014-15, and eight N and P rate experiments in South Dakota in 2014-15, with 48 total experiments taken to yield.

The results from these studies indicate that yield is independent of N rate, meaning that any formula of (Yield X (a factor) = N rate) is incorrect and nonpredictive in North Dakota. Nitrogen rate is related to relative yield within an environment, not actual yield. In addition, the recommendations account for the greater susceptibility to lodging with higher N rates and the relationship between higher N rates and increased sunflower disease. Although in the absence of high wind and disease, higher yield might be possible with higher N rates than those in the recommendation tables or in the future N calculator for sunflower, sunflower growers assume a greater lodging and disease risk if they choose to use higher rates.

Nitrogen

The sunflower recommendations are regionally-based and tillage-based. Perhaps due to the deeper rooting nature of sunflower, soil texture had less effect on yield compared with clay texture effect on corn N use efficiency in previous studies. However, at most sites that were planted to sunflowers for the first time in more than 30 years or did not have a deep-rooted crop such as sugar beets or sunflowers

within the past five years, yield response was very slight, if any increase occurred. Oil content tended to be near or below 40 percent, even with zero added N. This would be possible only if these locations have some unaccounted-for deep N. The western North Dakota site that was not planted to sunflower for at least five years experienced a major drought in 2012, followed by relatively wet seasons in 2013-2015, which may have moved N downward in the soil. In the sunflower crop of 2015, the deeper N in this field likely was tapped, resulting in no yield increase with higher N rates and relatively low oil content in the seed. The sites in eastern North Dakota without sugar beet or sunflower in recent memory likewise did not have increased yield with higher N rates and had oil content that, even at the zero N rate, was below 40 percent.

If practical, new fields intended for sunflower should be sampled to a 4-foot depth to determine if deep N should be considered in N fertility recommendations. About 30 pounds of N from 2 to 4 feet in depth are assumed but not subtracted from N recommendations. If the 2- to 4-foot soil nitrate test is greater than 30 pounds N per acre, then the extra N should be subtracted from the total N recommendation.

If deeper soil sampling is not practical, an N nonlimiting area of a full rate of N based on the N calculator or the N recommendation tables should be applied, and about half the N calculator rate should be applied to the rest of the field. Using an active-optical sensor or “best-guess” assessment of color differences and vigor of the N nonlimiting area, compared with the rest of the field, a decision whether or not to apply additional N in-season could be made or not made between stage V-8 to R1 (approximately V12 to V14) using a side-dress applicator or high-clearance applicator (Figure 1). In fields without a history of sunflower, sugar beet or another deep-rooted crop such as safflower, no additional N likely needs to be applied.

Soil sampling to 2 feet in depth is very important for N recommendations in this region. Including soil test nitrate-N into analysis of N rate vs sunflower yield trials greatly increased the relationship of total known available N to relative yield in all regions.

There are differences in the response of sunflower in Eastern North Dakota compared to those in Western North Dakota (Figure 2- Map of ND). In addition, the Langdon Region is separated from the rest of Eastern North Dakota due to the small shale pieces the soil in this region contains. These shale pieces are the source of mineralizable, plant-available ammonium, causing these soils to act as a natural slow-release N fertilizer. The N recommended in the Langdon Region is less than in the rest of the Eastern Region.

In the state, long-term no-till sites, those sites with continuous no-till for at least 6 years, required less N to achieve maximum economic yield compared to sites under conventional tillage. Similar results have also been recorded in spring wheat/durum and in corn, whose recommendations also contain reduced N rates for long-term no-till management.

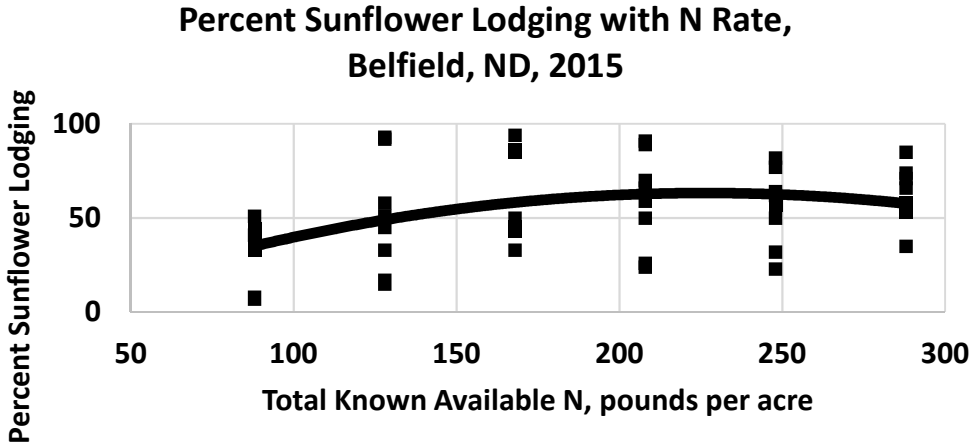
Some harvest loss is likely with lodging, so the upper values of N rate were reduced to limit lodging loss. Although white mold and downy mildew seemed to be related to N rate in experiment observation, only one site was rated for disease in each treatment. This site, north of Dickinson, N.D., was rated at harvest for sunflower rust, which is caused by the fungus *Puccinia helianthi*. The results of the rating are available in Table 1.

Table 1. Sunflower rust severity rating as a result of N rate, Dickinson, N.D., 2015.

N rate, lb. per acre	Sunflower rust rating*
0	0.65 a
40	1.51 ab
80	2.25 b
120	1.53 ab
160	1.25 ab
200	1.63 ab

*Ratings made on images obtained by retired agronomist Roger Ashley and rated by Samuel Markel, NDSU Extension plant pathologist.

Excessive wind resulting in sunflower root lodging or stalk breakage does not happen in every sunflower field every year, but lodging is a concern of most sunflower growers. Several research sites were affected by wind each year, and lodging severity was directly related to N rate (Figure 3 and Figure 4). Although in the N rate experiments all heads were included in yield, sunflower growers would suffer a decrease in harvest efficiency when sunflowers are on or near the ground. Therefore, the N rate is capped, even though small increases in yield and marginal profit might be possible with greater N rates in nonwind-affected growing seasons.



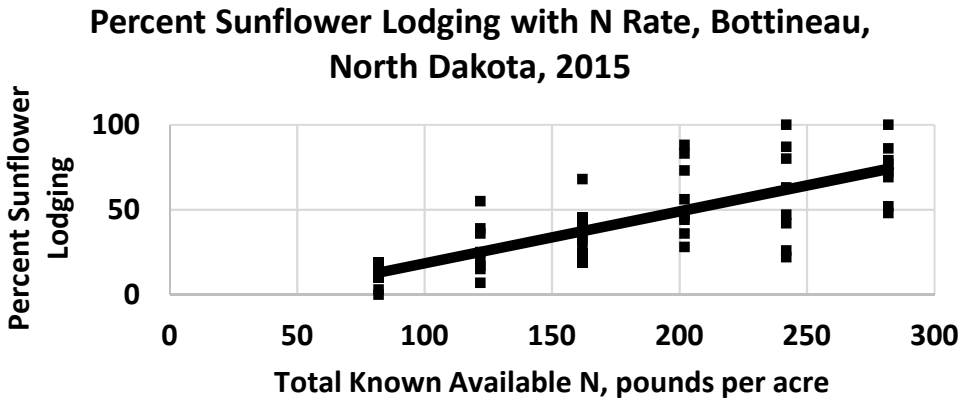


Figure 3. Percent sunflower lodging with increased available N at Belfield and Bottineau sites, 2015.

Seed oil content of oil-seed sunflowers always decreased with N rate, regardless of yield response. The economic impact of available N on yield response, seed oil response and N cost is factored into each N recommendation. Highest N rates are moderated due to possible harvestable yield reduction due to lodging. The N rate recommendations are available in Tables 2-13.

Table 2. Eastern Region conventional tillage confection sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	160	107	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	160	155	107	59	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	160	160	145	107	69	30	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	160	160	160	139	107	75	43	11	0	0	0	0	0	0	0	0	0	0	0
0.21	160	160	160	160	134	107	79	52	25	0	0	0	0	0	0	0	0	0	0
0.24	160	160	160	160	155	131	107	83	59	24	11	0	0	0	0	0	0	0	0
0.27	160	160	160	160	160	149	128	107	86	64	43	22	0	0	0	0	0	0	0
0.30	160	160	160	160	160	160	145	126	107	88	68	49	30	11	0	0	0	0	0
0.33	160	160	160	160	160	160	160	142	139	107	89	72	55	37	20	0	0	0	0
0.36	160	160	160	160	160	160	160	155	151	123	107	91	75	57	43	27	11	0	0
0.39	160	160	160	160	160	160	160	160	160	136	119	107	92	77	63	48	33	20	0
0.42	160	160	160	160	160	160	160	160	160	160	134	120	107	93	79	64	52	38	25
0.45	160	160	160	160	160	160	160	160	160	160	147	132	120	107	94	81	68	56	43
0.48	160	160	160	160	160	160	160	160	160	160	160	143	131	119	107	96	83	71	59
0.51	160	160	160	160	160	160	160	160	160	160	160	152	141	129	118	107	96	84	73
0.55	160	160	160	160	160	160	160	160	160	160	160	160	152	142	131	121	110	100	89
0.60	160	160	160	160	160	160	160	160	160	160	160	160	160	155	144	136	126	116	107

* Total known available N includes soil test N to 2 feet, previous crop credit and fertilizer amendment N rate.

Table 3. Eastern Region conventional tillage oilseed sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	150	135	124	111	96	84	72	59	47	35	23	12	0	0	0	0	0	0	0
0.12	150	145	135	125	116	106	96	87	78	68	59	50	41	32	23	14	0	0	0
0.15	150	150	143	135	127	119	112	104	96	89	81	74	67	59	52	45	38	30	23
0.18	150	150	148	141	135	128	126	115	109	103	96	90	84	78	72	65	59	53	47
0.21	150	150	150	146	141	135	129	124	118	113	107	102	96	91	86	80	75	70	65
0.24	150	150	150	150	145	140	130	130	125	120	115	111	106	101	95	91	87	83	78
0.27	150	150	150	150	148	144	135	135	131	126	122	118	113	109	105	102	96	92	88
0.30	150	150	150	150	150	147	139	139	135	131	127	123	119	115	112	108	104	100	96
0.33	150	150	150	150	150	150	150	150	138	135	131	128	124	121	117	116	110	107	103
0.36	150	150	150	150	150	150	150	150	142	138	135	132	128	125	122	119	115	112	109
0.39	150	150	150	150	150	150	150	150	144	141	138	135	132	129	126	123	120	117	114
0.42	150	150	150	150	150	150	150	150	146	143	141	138	135	132	129	127	124	121	118
0.45	150	150	150	150	150	150	150	150	148	145	143	140	138	135	132	130	127	124	122
0.48	150	150	150	150	150	150	150	150	150	147	145	142	140	137	135	132	130	128	125
0.51	150	150	150	150	150	150	150	150	150	150	147	144	142	140	137	135	133	130	128
0.55	150	150	150	150	150	150	150	150	150	150	150	146	144	142	140	138	136	134	131
0.60	150	150	150	150	150	150	150	150	150	150	150	148	146	144	142	141	139	137	135

* Total known available N includes soil test N to 2 feet, previous crop credit and fertilizer amendment N rate.

Table 4. Eastern Region long-term no-till oilseed sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	67	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	89	47	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	100	67	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	100	82	55	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.24	100	92	69	45	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.27	100	100	80	58	37	15	0	0	0	0	0	0	0	0	0	0	0	0	0
0.30	100	100	89	68	49	30	11	0	0	0	0	0	0	0	0	0	0	0	0
0.33	100	100	95	76	60	40	23	0	0	0	0	0	0	0	0	0	0	0	0
0.36	100	100	100	84	67	51	35	19	0	0	0	0	0	0	0	0	0	0	0
0.39	100	100	100	90	75	60	44	30	15	0	0	0	0	0	0	0	0	0	0
0.42	100	100	100	96	81	67	53	39	25	12	12	0	0	0	0	0	0	0	0
0.45	100	100	100	100	87	74	61	47	35	22	22	0	0	0	0	0	0	0	0
0.48	100	100	100	100	92	80	67	55	43	30	30	0	0	0	0	0	0	0	0
0.51	100	100	100	100	97	85	73	61	50	38	38	16	0	0	0	0	0	0	0
0.55	100	100	100	100	100	91	80	69	58	47	47	26	16	0	0	0	0	0	0
0.60	100	100	100	100	100	97	87	77	67	57	57	38	28	18	10	0	0	0	0

* Total known available N includes soil test N to 2 feet, previous crop credit and fertilizer amendment N rate.

Table 5. Eastern Region long-term no-till confection sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	77	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	99	57	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	110	77	46	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	110	92	65	37	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.24	110	102	79	55	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.27	110	110	90	68	47	25	0	0	0	0	0	0	0	0	0	0	0	0	0
0.30	110	110	99	78	59	40	21	0	0	0	0	0	0	0	0	0	0	0	0
0.33	110	110	105	86	70	50	33	10	0	0	0	0	0	0	0	0	0	0	0
0.36	110	110	110	94	77	61	45	29	0	0	0	0	0	0	0	0	0	0	0
0.39	110	110	110	100	85	70	54	40	25	0	0	0	0	0	0	0	0	0	0
0.42	110	110	110	106	91	77	63	49	35	22	22	0	0	0	0	0	0	0	0
0.45	110	110	110	110	97	84	71	57	45	32	32	0	0	0	0	0	0	0	0
0.48	110	110	110	110	102	90	77	65	53	40	40	10	0	0	0	0	0	0	0
0.51	110	110	110	110	107	95	83	71	60	48	48	26	10	0	0	0	0	0	0
0.55	110	110	110	110	110	101	90	79	68	57	57	36	26	10	0	0	0	0	0
0.60	110	110	110	110	110	107	97	87	77	67	57	48	38	28	20	0	0	0	0

* Total known available N includes soil test N to 2 feet, previous crop credit and fertilizer amendment N rate.

Table 6. Langdon Region conventional tillage, confection sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	120	67	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	120	115	67	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	120	120	105	67	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	120	120	120	99	67	35	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	120	120	120	120	94	67	39	12	0	0	0	0	0	0	0	0	0	0	0
0.24	120	120	120	120	115	91	67	43	19	0	0	0	0	0	0	0	0	0	0
0.27	120	120	120	120	120	109	88	67	46	24	0	0	0	0	0	0	0	0	0
0.30	120	120	120	120	120	120	105	86	67	48	28	0	0	0	0	0	0	0	0
0.33	120	120	120	120	120	120	120	102	99	67	49	10	15	0	0	0	0	0	0
0.36	120	120	120	120	120	120	120	115	111	83	67	32	35	17	0	0	0	0	0
0.39	120	120	120	120	120	120	120	120	120	96	94	51	52	37	10	10	0	0	0
0.42	120	120	120	120	120	120	120	120	120	108	107	67	67	53	24	24	12	0	0
0.45	120	120	120	120	120	120	120	120	120	120	120	80	80	67	41	41	28	16	0
0.48	120	120	120	120	120	120	120	120	120	120	120	92	91	79	56	56	43	31	19
0.51	120	120	120	120	120	120	120	120	120	120	120	112	101	89	67	67	56	44	33
0.55	120	120	120	120	120	120	120	120	120	120	120	120	112	102	91	81	70	60	49
0.60	120	120	120	120	120	120	120	120	120	120	120	120	120	115	104	96	86	76	67

Table 7. Langdon Region conventional tillage, oilseed sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	110	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	110	115	57	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	110	110	105	57	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	110	110	110	89	57	25	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	110	110	110	110	84	57	29	0	0	0	0	0	0	0	0	0	0	0	0
0.24	110	110	110	110	105	81	57	33	10	0	0	0	0	0	0	0	0	0	0
0.27	110	110	110	110	110	99	78	57	36	14	0	0	0	0	0	0	0	0	0
0.30	110	110	110	110	110	110	95	76	57	38	18	0	0	0	0	0	0	0	0
0.33	110	110	110	110	110	110	110	92	89	57	39	0	0	0	0	0	0	0	0
0.36	110	110	110	110	110	110	110	115	91	73	57	32	25	10	0	0	0	0	0
0.39	110	110	110	110	110	110	110	110	110	86	84	41	32	27	0	0	0	0	0
0.42	110	110	110	110	110	110	110	110	110	98	97	57	57	43	14	14	0	0	0
0.45	110	110	110	110	110	110	110	110	110	110	110	70	70	57	31	31	18	10	0
0.48	110	110	110	110	110	110	110	110	110	110	110	82	81	69	46	46	33	21	10
0.51	110	110	110	110	110	110	110	110	110	110	110	92	91	79	57	57	46	34	23
0.55	110	110	110	110	110	110	110	110	110	110	110	110	102	92	81	71	60	50	39
0.60	110	110	110	110	110	110	110	110	110	110	110	110	110	115	94	86	76	66	57

Table 8. Langdon Region, long-term no-till confection sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	69	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	80	47	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	80	62	35	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.24	80	72	49	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.27	80	80	60	38	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.30	80	80	69	48	29	10	0	0	0	0	0	0	0	0	0	0	0	0	0
0.33	80	80	75	56	40	20	10	0	0	0	0	0	0	0	0	0	0	0	0
0.36	80	80	80	64	47	31	15	0	0	0	0	0	0	0	0	0	0	0	0
0.39	80	80	80	70	55	40	24	10	0	0	0	0	0	0	0	0	0	0	0
0.42	80	80	80	76	61	47	33	19	10	0	0	0	0	0	0	0	0	0	0
0.45	80	80	80	80	67	54	41	27	15	10	10	0	0	0	0	0	0	0	0
0.48	80	80	80	80	72	60	47	35	23	10	10	0	0	0	0	0	0	0	0
0.51	80	80	80	80	77	65	53	41	30	18	18	0	0	0	0	0	0	0	0
0.55	80	80	80	80	80	71	60	49	38	27	27	16	0	0	0	0	0	0	0
0.60	80	80	80	80	80	77	67	57	47	37	27	18	18	0	0	0	0	0	0

Table 9. Langdon Region, long-term no-till oilseed sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	59	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	70	37	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	70	52	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.24	70	62	39	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.27	70	70	50	28	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.30	70	70	59	38	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.33	70	70	65	46	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0
0.36	70	70	70	54	37	21	10	0	0	0	0	0	0	0	0	0	0	0	0
0.39	70	70	70	70	45	30	14	0	0	0	0	0	0	0	0	0	0	0	0
0.42	70	70	70	70	51	37	23	10	0	0	0	0	0	0	0	0	0	0	0
0.45	70	70	70	70	57	44	31	17	10	0	0	0	0	0	0	0	0	0	0
0.48	70	70	70	70	62	50	37	25	15	0	0	0	0	0	0	0	0	0	0
0.51	70	70	70	70	67	55	43	31	20	10	10	0	0	0	0	0	0	0	0
0.55	70	70	70	70	70	61	50	39	28	17	17	10	0	0	0	0	0	0	0
0.60	70	70	70	70	70	67	57	27	37	27	17	10	10	0	0	0	0	0	0

Table 10. Western Region long-term no-till confection sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	86	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	110	75	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	110	95	66	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	110	110	86	61	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	110	110	100	79	58	38	0	0	0	0	0	0	0	0	0	0	0	0	0
0.24	110	110	110	92	73	55	38	20	0	0	0	0	0	0	0	0	0	0	0
0.27	110	110	110	102	85	69	55	38	22	0	0	0	0	0	0	0	0	0	0
0.30	110	110	110	110	95	81	69	52	38	26	0	0	0	0	0	0	0	0	0
0.33	110	110	110	110	102	90	81	65	52	39	27	0	0	0	0	0	0	0	0
0.36	110	110	110	110	110	100	90	73	63	51	39	28	0	0	0	0	0	0	0
0.39	110	110	110	110	110	110	100	82	73	61	50	39	29	0	0	0	0	0	0
0.42	110	110	110	110	110	110	110	89	81	70	60	50	39	39	29	0	0	0	0
0.45	110	110	110	110	110	110	110	99	88	78	68	58	49	49	39	11	0	0	0
0.48	110	110	110	110	110	110	110	101	94	85	75	66	57	57	48	23	12	0	0
0.51	110	110	110	110	110	110	110	106	99	90	82	73	65	65	56	31	21	13	0
0.55	110	110	110	110	110	110	110	110	106	95	89	81	73	73	65	40	32	24	17
0.60	110	110	110	110	110	110	110	110	110	105	97	90	83	83	75	51	44	37	29

Table 11. Western Region long-term no-till oilseed sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	76	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	100	65	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	100	85	56	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	100	100	76	51	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	100	100	100	69	48	28	0	0	0	0	0	0	0	0	0	0	0	0	0
0.24	100	100	100	82	63	45	28	10	0	0	0	0	0	0	0	0	0	0	0
0.27	100	100	100	92	75	59	45	28	12	0	0	0	0	0	0	0	0	0	0
0.30	100	100	100	100	85	71	59	42	28	16	0	0	0	0	0	0	0	0	0
0.33	100	100	100	100	102	80	71	55	42	29	17	0	0	0	0	0	0	0	0
0.36	100	100	100	100	100	100	80	63	53	41	29	18	0	0	0	0	0	0	0
0.39	100	100	100	100	100	100	100	72	63	51	40	29	19	0	0	0	0	0	0
0.42	100	100	100	100	100	100	100	79	71	60	50	40	29	29	19	0	0	0	0
0.45	100	100	100	100	100	100	100	89	78	68	58	48	39	39	29	0	0	0	0
0.48	100	100	100	100	100	100	100	91	84	75	65	56	47	47	38	13	0	0	0
0.51	100	100	100	100	100	100	100	96	89	80	72	63	55	55	46	21	11	0	0
0.55	100	100	100	100	100	100	100	100	96	85	79	71	63	63	55	30	22	14	10
0.60	100	100	100	100	100	100	100	100	100	95	87	80	73	73	65	41	34	27	19

Table 12. Western Region conventional tillage, confection sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	136	87	40	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	160	105	87	40	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	160	145	116	87	60	40	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	160	160	136	111	88	60	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	160	160	160	129	108	88	40	20	0	0	0	0	0	0	0	0	0	0	0
0.24	160	160	160	142	123	105	78	60	20	0	0	0	0	0	0	0	0	0	0
0.27	160	160	160	152	135	119	105	88	62	20	0	0	0	0	0	0	0	0	0
0.30	160	160	160	160	145	131	119	102	88	66	20	0	0	0	0	0	0	0	0
0.33	160	160	160	160	160	140	131	115	102	89	77	20	0	0	0	0	0	0	0
0.36	160	160	160	160	160	160	140	123	113	101	89	58	20	0	0	0	0	0	0
0.39	160	160	160	160	160	160	160	132	123	111	100	89	79	20	0	0	0	0	0
0.42	160	160	160	160	160	160	160	139	131	120	110	100	89	59	20	0	0	0	0
0.45	160	160	160	160	160	160	160	149	138	128	118	108	99	89	69	20	0	0	0
0.48	160	160	160	160	160	160	160	151	144	135	125	116	107	97	88	53	20	0	0
0.51	160	160	160	160	160	160	160	156	149	140	132	123	115	105	96	81	41	20	0
0.55	160	160	160	160	160	160	160	160	156	145	139	131	123	113	105	90	72	54	30
0.60	160	160	160	160	160	160	160	160	160	155	147	140	133	123	115	101	94	87	79

Table 13. Western Region conventional tillage, oilseed sunflower N recommendations based on N cost and sunflower price.

Sunflower $ per pound	N cost $ per pound																		
	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00
	Total Known Available N Recommended, pounds per acre*																		
0.09	136	77	30	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.12	150	95	77	30	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.15	150	135	106	87	50	30	0	0	0	0	0	0	0	0	0	0	0	0	0
0.18	150	150	126	101	78	50	0	0	0	0	0	0	0	0	0	0	0	0	0
0.21	150	150	150	119	98	78	30	10	0	0	0	0	0	0	0	0	0	0	0
0.24	150	150	150	132	113	95	68	50	10	0	0	0	0	0	0	0	0	0	0
0.27	150	150	150	142	115	109	95	78	52	10	0	0	0	0	0	0	0	0	0
0.30	150	150	150	150	135	121	109	92	78	56	10	0	0	0	0	0	0	0	0
0.33	150	150	150	150	150	130	121	105	92	79	67	10	0	0	0	0	0	0	0
0.36	150	150	150	150	150	150	130	113	103	91	79	48	10	0	0	0	0	0	0
0.39	150	150	150	150	150	150	140	122	113	101	90	79	69	10	0	0	0	0	0
0.42	150	150	150	150	150	150	150	129	121	110	100	90	79	49	10	0	0	0	0
0.45	150	150	150	150	150	150	150	139	128	118	108	98	89	79	59	10	0	0	0
0.48	150	150	150	150	150	150	150	141	134	125	115	106	97	87	78	43	10	0	0
0.51	150	150	150	150	150	150	150	146	139	130	122	113	105	95	86	71	31	10	0
0.55	150	150	150	150	150	150	150	150	146	135	129	121	113	103	95	80	62	44	20
0.60	150	150	150	150	150	150	150	150	150	145	137	130	123	113	105	91	84	77	69

Phosphorus

High soil test phosphorus (P) values and application of P fertilizer have not been found necessary for high sunflower yields in U.S. studies. There is no evidence that fallow induces P deficiency in sunflower as it does in corn, despite the high reliance of sunflower on mycorrhiza.

Forty site-years of N and P rate experiments were conducted in western Nebraska during 1993 and 1994. Researchers found no effect of P rate on sunflower yield at any location. Most of the Nebraska sites had medium to high soil P levels, but some sites were classified in the low soil P range and yet did not respond to P (Geleta et al., 1997).

Of the 48 P rate experiments in North Dakota and South Dakota, only three had statistically greater yield, with P rates from 60 to 90 pounds of P_2O_5 per acre, compared with the check. At only one site was the yield increase economically beneficial when the cost of the P fertilizer was considered.

The recommendation for P fertilizer for sunflower in this region therefore is **zero**. Although the application of P fertilizer can be made and does not decrease yield, neither does it economically increase yield. Soil test P was not related to P response. Sunflower P removal in grain is very low, with only about 10 pounds of P_2O_5 per acre removed with a 2,000-pound-per-acre seed yield.

Potassium

Potassium (K) has been studied little in the region for sunflower. Around the world, K rate studies indicate that about 150 parts per million (ppm) from the standard K test in the region is sufficient for maximum sunflower yield.

South Dakota data from corn K rate studies indicate that if soil K levels are below 150 ppm, about 100 pounds per acre of 0-0-60 is necessary to maximize yields in any year. Therefore, if the soil test is below 150 ppm, the K fertilizer rate is a flat 100 pounds per acre rate of 0-0-60, or 60 pound per acre of K_2O.

Sulfur

Sulfur (S) has become a common nutrient that is deficient for many crops in North Dakota. Although sunflower is deeply rooted, and in many soils, the groundwater is high in sulfates, sunflower may be susceptible to early season deficiency. The S soil test is not diagnostic.

A better prediction for possible S deficiency would be noting fall rainfall, winter snowfall, spring snowmelt and rainfall before planting. If any high precipitation is experienced, the possibility of S deficiency is greater.

Loam and coarser-textured soils are most susceptible to S deficiency. If S is anticipated to be deficient, an application of 10 pounds of S as a sulfate or thiosulfate source is recommended as preplant or postemergence before the reproductive stage (R1) of growth.

Elemental S application is not recommended. Do not apply any thiosulfate fertilizer with the seed. Also, S is a spring fertilizer, so fall application is not recommended due to the likelihood of leaching in the spring before planting.

Other Nutrients

Of all the micronutrients, sunflower is most susceptible to boron (B) deficiency from reports around the world. However, in North Dakota, B rate experiments with soil B levels as low as 0.2 ppm showed no sunflower yield response with B application. Thus, no micronutrient application, including B application, is needed in North Dakota.

Organic Sunflower Nutrient Management

With the current market for organic foods of all kinds, sunflower lends itself well to certified organic production. For the requirements in North Dakota, contact the North Dakota Organic Advisory Board (www.ndorganics.nd.gov/) for a list of U.S. Department of Agriculture-vetted certifiers.

Organic systems usually are depleted of N, but soil sampling can be helpful in determining the need for supplemental N amendments. One strategy organic growers use is to grow an early maturing crop, such as barley or winter wheat, the year before sunflowers and grow a cover crop of a fast-growing annual legume directly after grain harvest.

Compost also can be used to great advantage. The compost should come from a reliable source, where the manure was brought to temperatures that kill weed seed. Well-made composts can be sampled and analyzed for N content so that a better estimate can be made of N release during the sunflower growing year. A guide to producing and managing compost is available at www.ag.ndsu.edu/manure/documents/nm1478.pdf.

Compost also will contain substantial potassium, which might be limiting on very sandy soils, as well as sulfur. Sulfur fertilizers that also can be used include gypsum from natural sources and potassium sulfate (check with the North Dakota Organic Advisory Board for details).

Sunflower is susceptible to lodging and greater susceptibility to disease when too much N is applied, so rates of estimated available N should be conservative and should not exceed 150 pounds of N per acre. No micronutrient considerations are necessary for organic sunflower production in North Dakota.

References

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Figure 2. Side-dressing ammonia on sunflowers about V8. Photo courtesy of Don Lilliboe.

Sunflowers ready to harvest near Bottineau, N.D., 2015.

Figure 4. Sunflowers near harvest with significant lodging due to strong winds in a July thunderstorm.

Sunflower early bloom, near Elgin, N.D., 2015.

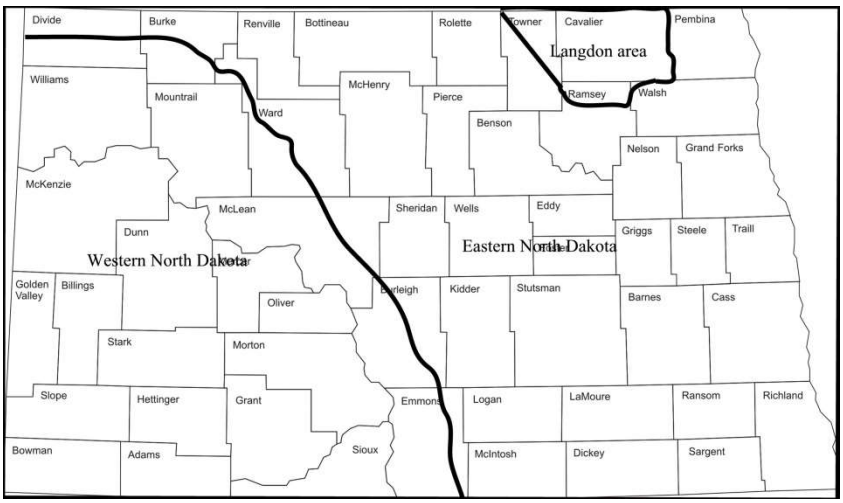

Figure 1. Regions of Eastern North Dakota, the Langdon Area and Western North Dakota important to North Dakota sunflower N recommendations. Soils in the Langdon Area contain small pieces of shale that release N during the growing season, making the N rate recommendations for Langdon less than those in the rest of Eastern North Dakota.