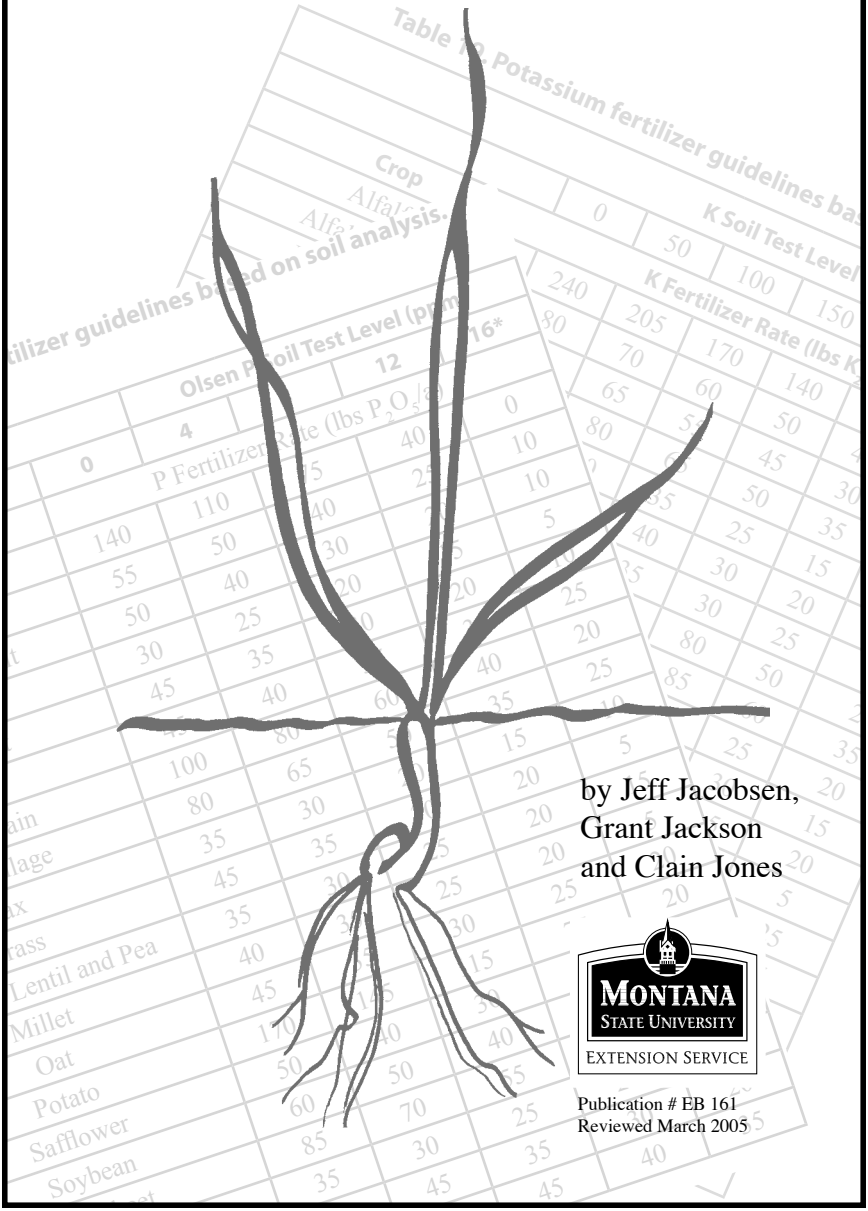
FERTILIZER GUIDELINES
for Montana Crops



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Fertilizer Guidelines for Montana Crops

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Contents

Introduction

Nitrogen (N), phosphorus (P), potassium (K) and other fertilizers can increase crop yield and quality when soil analysis indicates deficiencies, soil nutrients are unavailable, past history would predict a response, and other agronomic practices are optimum. The following soil analysis guidelines (Tables 1-17 for N, 18 for P, 19 for K, and 20 for micronutrients) are primarily based on research conducted in Montana, but where current or any data is not available, we have used a compilation of research from surrounding states and provinces to develop the tables.

These tables provide guidelines in terms of fertilizer rates for a range of yield potentials, available N and soil analysis values for P, K and micronutrients. Fertilizer guidelines assume that growth-limiting factors such as sodium and salts are not limiting growth.

Nitrogen

The soil analysis for available N is for NO_3-N to a depth of 2 feet. Deeper soil samples for N or other soil mobile nutrients (sulfur, boron and chloride) will improve the reliability of N and other mobile nutrient fertilizer guidelines. When organic matter mineralizes it has the potential to release N into the soil for potential plant uptake. The Montana N fertilizer guidelines assume an average organic matter level of 2%. This is directly incorporated into our recommendations on available N requirements. For soils that have organic matter (O.M.) levels that exceed 2%, additional N will be released to the soil through mineralization at a rate of 15-20 lbs N/a for each 1% of O.M. Therefore, N fertilizer rates can be decreased by 15-20 lbs N/a, if the soil has 3% O.M. or more. With small grain residues remaining on the soil surface and broadcast N applications, 10 lbs N/a can be added per 1000 lb residue/a, up to a total of 40 lbs N/a. Montana research indicates that additional N is not needed. Split N applications may be warranted on coarse-textured soils.

Phosphorous and Potassium

Phosphorus and K guidelines (Tables 18 and 19) are based on a sample taken from 6 inches in depth and assume band placement of fertilizer material. The P and /or K rate may need to be increased for broadcast applications particularly on low to medium testing soils or where past experience has indicated a response to applied fertilizer.

Potassium fertilizer response information is accurate approximately 30% of the time. Therefore, site- and year-specific response information is particularly important. Starter applications (10-20 lbs nutrient/a) are recommended for all crops (particularly spring crops), since the soils are typically cold and ideally wet, which limits the initial availability of residual N, P, and K.

Variability within Sites

The soil analysis values are based on soil samples that represent a field or areas within a field. Interpolation may be necessary to determine the suggested level of a specific nutrient to be applied. Special condition comments are provided to enhance nutrient management practices and, in particular, avoid problems and optimize inputs. P and K recommendations are independent of yield and are based on typical yields for Montana. Table 21 provides crop replacement/removal values for the harvested portion, if needed.

Applying Site-specific Information

When site-specific information is available or is known through actual field experiences, use it to develop unique guidelines for fertilizer applications. The research-based information presented in these tables is from multiple sites over multiple years, spanning unique environments and, ultimately, representing average response information for Montana and the Northern Great Plains. Therefore, this information will not take into account annual variability in climate prior to and during the growing season. Without question, local expertise should be used to ultimately determine fertilizer rates.

Adapting to your Conditions

The guidelines are for a single season of cropping and do not represent a build- or fertilize-the-soil philosophy. Based on economics, soil factors and level of management, a land manager may want to put more P and/or K in a field in a given year. Assuming no soil erosion occurs (for P and K losses) or leaching (for N losses), these agronomic rates will not impact water quality.

Specific differences in soil, climate, management intensity and other unique site factors should be integrated into final decisions on fertilizer rates. General crop removal rates for numerous essential elements are presented in Table 21. These are based on the dry matter unit presented, using the best available data. These should not be considered absolute, since factors such as cultivar, climate and agronomic practices can influence nutrient concentrations.

Sulfur and Micronutrients

Although sulfur (S) guidelines are not presented, deficiencies are increasingly common on Montana soils with low soil S levels, low gypsum levels, or when gypsum is present, but it is positioned in the soil profile out of the rooting zone. Compounding this diagnostic problem is the fact that the analytical procedures for S soil analysis sometimes do not accurately reflect or relate to crop response from S fertilizer applications. Canola and forages have been demonstrated to be responsive to S applications.

General micronutrient guidelines are presented based on a 6-inch sample depth. However, deficiencies are not common, so minimal research has been conducted on micronutrients in the Northern Great Plains.

Table 1. Alfalfa/grass N guidelines.

ALFALFA/GRASS				
Yield Potential (t/a)*	80/20	60/40	40/60	20/80
	————Available N (lbs/a)**————			
1	5	10	15	20
2	10	20	30	40
3	15	30	45	60
4	20	40	60	80
5	25	50	75	100
6	30	60	90	120

*Attainable yield when ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- Inoculation with nodule forming N-fixing bacteria is advised for establishment of legumes on fields not previously cropped to legumes.
- Inoculation is essential to meet N demand from N fixation, if native inoculum is not sufficient.
- Plowed down alfalfa stubble adds some fixed N to the soil. In general, the first crop after alfalfa or sweet clover will add 35-50 lbs N/a.
- Broadcasting is the most efficient method of fertilizer application on established perennial crops. Recent data show deep band applications of P in old alfalfa stands is effective.
- Under dryland conditions and low P/K soil levels, it would be better to "build up" or increase the available level of P and/or K in the soil before planting alfalfa or other perennial hay crops.
- For established alfalfa when fertilizer is recommended, the above fertilizer is to be applied annually as long as the stand is maintained.
- For all new grass seedings, the above recommendation is for the seeding year and subsequent annual applications. For the seeding year, do not apply more than 20 lbs N/a.
- The above recommendation may be applied for cool season grasses in the late fall or early spring. For warm season grasses, apply about mid-May.
- N fertilization of grass-legume mixtures will usually increase the grass yield in relation to legumes. Legumes will be more competitive, if phosphorus (P) rates are adequate.
- Frequently, the legume percentage in the forage can be increased by applying high rates of P and little or no N fertilizer. If more than 50% of the plants are legumes, assuming good stands and available water, lack of P in soil is the major cause of poor production.

Table 2. Feed and malt barley N guidelines based on soil analysis.

BARLEY - FEED	
Yield Potential (bu/a) *	**Available N (lbs/a) ****
40	64
60	96
80	128
100	160
120	192
140	224

BARLEY - MALT	
Yield Potential (bu/a) *	**Available N (lbs/a) ****
60	72
70	84
80	96
90	108
100	120
110	132
120	144

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- Drill-row applications of N+K_2O should not exceed 30 lbs/a. When using urea as the N source, drill-row applications of N+K_2O should not exceed 15 lbs/a with a 6-7 inch row spacing. When using a wider row spacing, do not apply any urea with the seed. With newer drills and openers, the mixture of seed, fertilizer and soil is much greater, so more fertilizer can be placed in the "row" due to the dilution of potential detrimental impacts from salts and ammonia on germination and growth.
- Applying N fertilizer on well-drained sandy soils in the fall is not recommended because of possible loss by leaching.
- If protein levels of malt barley produced on your fields have been over acceptable levels, reduce the recommended rates by 20 lbs N/a.
- Fertilization with K at 20 (dryland) to 30 (irrigated) lbs K_2O/a is generally recommended for malt barley regardless of soil analysis.
- Barley grown for hay should be fertilized with the above N guidelines. If any plant stress (e.g. drought) is present, the potential hay should be checked for nitrates.

Table 3. Dry Bean N guidelines based on soil analysis.

DRY BEAN	
Yield Potential (lbs/a) *	**Available N (lbs/a) ****
1000	50
1400	70
1800	90
2200	110
2600	130
3000	150

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- Dry edible beans are legumes which respond to N fertilizer and are very salt sensitive. If N is applied as a starter, it should not be in contact with the seed. Inoculation is essential to help meet N demand from N fixation. Some bush-type varieties will use more N for pod production compared to vine-type varieties.
- It usually takes several weeks after emergence for legumes to start producing their own N and dry beans are very ineffective in fixing N. Use of higher rates of N, however, may slow maturing and increase harvest problems. Responses to P and K are not always noticeable in the year of application. Approximately 60 percent of the P and 50 percent of the K used by edible bean plants is removed from the field when the seed is harvested.
- Dry bean can be N deficient even though they are legumes. Such deficiency can occur with cool wet growing conditions, especially in the first weeks of growth. Also, poor nodulation and/or inefficient strains of Rhizobia will fix less N than the plants require, resulting in N deficiency.
- Dry bean is sensitive to Zn and Fe deficiencies. High P can induce Zn deficiencies, even at adequate soil test levels.
- With an Fe soil test below 3.0 ppm, Fe availability is low. With an Fe soil test of 3.0-5.0 ppm, Fe availability is marginal. Direct Fe fertilization usually does not produce an economic return, and as the season warms up and the soil dries out, more Fe may become available to the crop. Incorporation of O.M. and improved drainage can help Fe availability. Also, avoid planting dry bean after sugarbeet, particularly if residual soil NO_3-N levels are high.
- Zn recommendation is based on use of inorganic product such as zinc sulfate which is broadcast and plowed down. One application should be effective for 2 to 4 years. Banding near the seed (2x2) has been found to be more effective per lb Zn than broadcast or incorporated applications.

Table 4. Buckwheat N guidelines based on soil analysis.

BUCKWHEAT	
Yield Potential (bu/a) *	**Available N (lbs/a) ****
25	55
30	66
35	77
40	88
45	99
50	110

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- N+K_2O applications in contact with the seed should not exceed 10 lbs/a. N from urea, and DAP (18-46-0) should NOT be placed with the seed.

Table 5. Canola/mustard/rapeseed N guidelines based on soil analysis.

CANOLA/MUSTARD/RAPESEED	
Yield Potential (lbs/a) *	**Available N (lbs/a) ****
800	52
1200	78
1600	104
2000	130
2400	156
2800	182

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- N+K_2O applications in contact with the seed should not exceed 10 lbs/a. Nitrogen from urea, and DAP (18-46-0) should NOT be placed with the seed.
- Apply 20 lbs S/a as sulfate for each canola crop in a preplant application.

Table 6. Grain and silage corn N guidelines based on soil analysis.

CORN - GRAIN		CORN - SILAGE	
Yield Potential (bu/a) *	**Available N (lbs/a) ****	**Yield Potential (t/a) ***	**Available N (lbs/a) ****
50	60	12	108
90	108	15	135
130	156	18	162
170	204	21	189
210	252	24	216
250	300	27	243

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- If starter fertilizer is used, with seed and fertilizer applied together, rates should not exceed 5 to 10 lbs N/a, 10 lbs of P_2O_5/a and 5 lbs of K_2O/a. On sandy soils, such rates may damage germination because these soils are more likely to dry out before the crop is up. If the fertilizer implement places the fertilizer in a band that is to the side and below the seed, you can generally apply the entire recommended rate with the planter.
- Corn is sensitive to inadequate levels of Zn, and deficiency symptoms are occasionally observed in irregular patterns on soils of the Yellowstone Valley, especially where topsoil has been removed by land leveling. Zinc deficiencies may be aggravated by high rates of P.
- Reduce seed placed fertilizer rate by 50%, when soil conditions are dry or sandy, particularly with N as urea, DAP (18-46-0) and ammonium thiosulfate (12-0-0-26).
- Sandy soils may require split N applications.
- Corn is sensitive to Zn and Fe deficiencies. High P can induce Zn deficiencies, even at adequate soil test levels.
- With an Fe soil test below 3.0 ppm, Fe availability is low. With an Fe soil test of 3.0-5.0 ppm, Fe availability is marginal. Direct Fe fertilization usually does not produce an economic return, and as the season warms up and the soil dries out, more Fe may become available to the crop. Incorporation of O.M. and improved drainage can help Fe availability.
- Zn recommendation is based on use of an inorganic product such as zinc sulfate which is broadcast and plowed down. One application should be effective for 2 to 4 years.

Table 7. Flax N guidelines based on soil analysis.

FLAX	
Yield Potential (bu/a) *	**Available N (lbs/a) ****
20	60
30	90
40	120
50	150

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- $N+K_2O$ applications in contact with the seed should not exceed 10 lbs/a. Nitrogen from urea, and DAP (18-46-0) should NOT be placed with the seed.

Table 8. Grass N guidelines based on soil analysis.

GRASS	
Yield Potential (t/a) *	**Available N (lbs/a) ****
1	25
2	50
3	75
4	100
5	125

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- Fall N application on sandy soils is not recommended. On all other soils, apply fertilizer in late fall or early spring. Continued application of N in late fall or early spring will favor the growth of cool season grasses at the expense of warm season grasses in native pasture, to enhance or promote the growth of warm season grasses, apply N in early summer.
- With a fluctuating water table (subirrigation), fertilize as though it is irrigated with a higher yield potential; however, be sure to apply P fertilizers in the fall or late winter.
- Hay meadows with reasonably good drainage can be fertilized any time from early winter to early spring. Wet meadows should be fertilized as close to spring as practical. Experiments show less yield increase from fall applications on very wet soils, but they are often profitable, so late winter fertilization may be the best alternative.
- Split N will generally not increase total production. If seeding on summerfallow, O. M. levels of 3% or more may produce enough plant available N to reduce rate of N fertilizer for 2 or 3 years.
- Do not exceed 60 lbs N/a during the seeding year, or within 9 months after a fall seeding date. If ammonium phosphate fertilizer is banded with the seed, for better efficiency of low rates, do not exceed 15 lbs N/a for 14 inch or less row spacings, and do not exceed 10 lbs N/a for rows spaced 18 inches or more. If N is placed with the seed, do not exceed 15 lbs N/a.
- If P is supplied by ammonium phosphate banded below the seed, do not exceed 15 lbs N/a for 14 inch or less row spacings and do not exceed 10 lbs N/a for rows spaced 18 inch or more. Fall application of P may give better first season response than spring application, particularly for low-medium P soils.

Table 9. Lentil/chickpea/pea N guidelines based on soil analysis.

LENTIL/CHICKPEA/PEA
Generally, no supplemental N is needed. However, under dryland conditions, 15-25 lbs N/a should be present in the top 2 feet of the soil profile. Under irrigated conditions 30-40 lbs N/a should be present in the top 2 feet of the soil profile. Supplemental N may be warranted based on the above criteria. Small amounts of N (<30 lbs N/a) with P fertilization will generally not harm the N-fixing capacity.

Special Conditions

- Legumes without nodules or with ineffective nodules will respond to N applications. Since legumes have the ability to fix N, it is important to inoculate the seed just before planting. This is especially true on fields that have not been recently planted to either crop.
- It is important to use the proper inoculant for pea and lentil, since specific legumes require specific strains of Rhizobia bacteria.
- Starter applications of 10 lbs N/a have been shown to minimize N deficiency during early nodulation particularly on soils low in clay content or with high levels of small grain residues.
- Pea and lentil crops fix from 20% to 80% of their N requirement and obtain the remainder from the soil or fertilizer.
- K application rates when applied with seeding should not exceed 15 lbs K_2O/a due to the potential for seedling damage. If N is applied, the K_2O rate should be decreased by one pound for each pound of nitrogen added with the seed.
- Montana research has shown that the N benefits following pulse crops (chickpea, lentil, pea) averages about 10 lbs/a, but can vary from 0 to 20 lbs N/a depending upon climate and soil conditions. N contributions from green fallowed pulse crops can be substantially higher, but research has not determined actual numbers.

Table 10. Millet/canary seed/sorghum N guidelines based on soil analysis.

MILLET/CANARY SEED/SORGHUM	
Yield Potential (lbs/a) *	**Available N (lbs/a) ****
1500	52
1800	63
2100	74
2400	85
2700	96
3000	107

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- Drill-row applications of N+K_2O should not exceed 10 lbs/a to avoid the possibility of germination damage.

Table 11. Oat N guidelines based on soil analysis.

OAT	
Yield Potential (bu/a) *	**Available N (lbs/a) ****
60	72
80	96
100	120
120	144
140	168
160	192

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- For oats, N+K_2O fertilizers should be limited to 25 lbs/a when placed in contact with the seed in 6 or 7 inch rows. Reduce these values correspondingly for wider row width. Reduce these amounts by half for dry or coarse textured soils.
- Oats grown for hay should be fertilized with the above N guidelines. If any plant stress (e.g. drought) is present, the hay should be checked for nitrates.

Table 12. Potato N guidelines based on soil analysis.

POTATO	
Yield Potential (cwt/a) *	**Available N (lbs/a) ****
200	80
300	120
400	160
500	200

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- With an Fe soil test below 3.0 ppm, Fe availability is low. With an Fe soil test of 3.0-5.0 ppm, Fe availability is marginal. Direct Fe fertilization usually does not produce an economic return, and as the season warms up and the soil dries out, more Fe may become available to the crop. Incorporation of O.M. and improved drainage can help Fe availability.
- Zn recommendation is based on use of an inorganic product such as zinc sulfate which is broadcast and plowed down. One application should be effective for 2 to 4 years.

Table 13. Safflower N guidelines based on soil analysis.

SAFFLOWER	
Yield Potential (lbs/a) *	**Available N (lbs/a) ****
750	38
1250	62
1750	88
2250	112
2750	138
3250	162

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- N+K_2O applications in contact with the seed should not exceed 10 lbs/a. Nitrogen from urea, and DAP (18-46-0) should NOT be placed with the seed.
- Drill-row applications of N+K_2O should not exceed 15 lbs/a to avoid the possibility of germination damage.
- Safflower is an excellent N scavenger to depths of 6 feet. Where long-term crop-fallow has been practiced, there is usually sufficient N below 4 feet to supply the majority of N required.

Table 14. Soybean N guidelines based on soil analysis.

SOYBEAN
Additional fertilizer N is generally not needed. The N associated with P fertilizer (18-46-0 and 11-52-0) applications up to 20-30 lbs N/a will generally not adversely impact N fixation.

Special Conditions

- Inoculation with nodule forming N-fixing bacteria is advised for establishment of new legumes or fields not previously used for legumes or combined fields with different cropping histories.
- Soybeans that have been well inoculated are not likely to respond to additional N fertilizer. Inoculation is essential to help meet N demand from N fixation.
- When planted in 30 inch rows, do not apply fertilizer in contact with the seed. When planted in 7 inch rows, limit seed placed $N+K_2O$ to 5 lbs/a, but do not use urea, UAN or DAP (18-46-0) and limit 0-46-0 to 100 lbs/a.

Table 15. Sugarbeet N guidelines based on soil analysis.

SUGARBEET	
Yield Potential (t/a) *	**Available N (lbs/a) ****
16	144
20	180
24	216
28	252
32	288

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- A general guide for spring applied N is to reduce the recommended N rate by 10 pounds for each week that planting is delayed after May 20.
- If the amount of NO_3-N in the 2- to 4-foot depth is more than 30 lbs N/a, the N recommendation should be reduced by 4 pounds for each 5-pound increment above 30 pounds found in the 2- to 4-foot depth.
- 10 to 15 lbs of N/a in the top 6 inches of soil should be adequate to establish the crop.
- Fall applied N fertilizer is not recommended on sandy soils or soils with a high water table.
- Late season release of N from manure can reduce sucrose percentage by stimulating top growth. For this reason, do not apply more than 15 tons of manure/a for a sugarbeets.
- In rotations with sugarbeets, if the tops remain in the field, reduce N requirements by 40 to 50 lbs N/a due to the release of N from this sugarbeet material.
- Sandy soils may require split N applications.
- Ridged beets should have no more than 80 lbs N/a applied preplant broadcast. This is more critical with urea compared to ammonium nitrate.

Table 16. Sunflower N guidelines based on soil analysis.

SUNFLOWER	
Yield Potential (lbs/a) *	**Available N (lbs/a) ****
1000	50
1300	65
1600	80
1900	95
2200	110
2500	125

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.

Special Conditions

- Some N may be applied in combination with starter fertilizers, but the rate should be less than 10 lbs N/a. Most efficient use can be obtained by applying N just ahead of planting. However, apply all of the fertilizer before heading (bud stage) to maximize yields and N use efficiency.
- Sunflower roots grow quickly into the soil between the rows. Sidedress N fertilizers early in the growing season to avoid root pruning.
- When planted in 30 inch rows, do not apply fertilizer in contact with the seed. When planted in 7 inch rows, limit seed placed N+K_2O to 5 lbs/a, but do not use urea, UAN or DAP(18-46-0) and limit 0-46-0 to 100 lbs/a.
- Sunflower is an excellent N scavenger to depths of 6 feet. Where long-term crop fallow has been practiced, there is usually sufficient N below 4 feet to supply the majority of N required.

Table 17. Spring and winter wheat N guidelines based on soil analysis.

WHEAT- SPRING***	
Yield Potential (bu/a) *	**Available N (lbs/a) ******
30	99
40	132
50	165
60	198
70	231
80	264
90	297
100	330

WHEAT- WINTER	
Yield Potential (bu/a)*	**Available N (lbs/a) ******
30	78
40	104
50	130
60	156
70	182
80	208
90	234

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.
***Includes durum and hard red and hard white spring wheat at 13% and 14% protein, respectively.

Special Conditions

- Drill-row applications of N+K_2O should not exceed 20 lbs/a. When using urea as the N source, drill-row application of N+K_2O should not exceed 10 lbs/a with a 6-7 inch row spacing. When using a wider row spacing, do not apply any urea with the seed. With newer drills and openers, the mixture of seed, fertilizer and soil is much greater, so more fertilizer can be placed in the "row" due to the dilution of potential detrimental impacts from salts and ammonia on germination and growth.
- If 14% protein is desired in winter wheat, use spring wheat guidelines.

Table 18. Phosphorus fertilizer guidelines based on soil analysis.

Crop	Olsen P Soil Test Level (ppm)				
	0	4	8	12	16*
	P Fertilizer Rate (lbs P_2O_5/a)				
Alfalfa	140	110	75	40	0
Alfalfa-Grass	55	50	40	25	10
Barley-Feed/Malt	50	40	30	20	10
Bean	30	25	20	15	5
Buckwheat	45	35	30	20	10
Canola	45	40	35	30	25
Corn-Grain	100	80	60	40	20
Corn-Silage	80	65	50	35	25
Flax	35	30	20	15	10
Grass	45	35	30	20	5
Lentil, Chickpea and Pea	35	30	25	20	15
Millet	40	35	25	20	5
Oat	45	35	30	25	20
Potato	170	145	115	75	20
Safflower	50	40	30	20	10
Soybean	60	50	40	25	5
Sugarbeet	85	70	55	40	10
Sunflower	35	30	25	20	15
Wheat-Spring	50	45	35	30	20
Wheat-Winter	55	50	45	40	35

Special Conditions

- With soil analysis levels of greater than 16 ppm, consider using crop removal rates (Table 21) as a P fertilization guideline.

Table 19. Potassium fertilizer guidelines based on soil analysis.

Crop	K Soil Test Level (ppm)					
	0	50	100	150	200	250
	K Fertilizer Rate (lbs K_2O/a)					
Alfalfa	240	205	170	140	95	30
Alfalfa-Grass	80	70	60	50	40	25
Barley-Feed	75	65	55	45	30	20
Barley-Malt	90	80	65	50	35	25
Bean	45	40	35	25	15	5
Buckwheat	60	50	40	30	20	5
Canola	45	40	35	30	25	20
Corn-Grain	135	120	100	80	50	20
Corn-Silage	145	125	110	85	60	35
Flax	45	40	35	30	25	20
Grass	80	70	60	45	30	15
Lentil, Chickpea and Pea	45	40	35	30	25	20
Millet	65	55	45	35	20	5
Oat	100	85	70	55	40	25
Potato	300	250	215	165	100	25
Safflower	65	55	45	35	25	15
Soybean	90	75	60	45	30	15
Sugarbeet	120	100	80	60	40	20
Sunflower	55	50	45	40	35	30
Wheat	135	115	90	70	40	10

Table 20. Micronutrient fertilizer guidelines based on soil analysis.

Micronutrient Soil Test* ppm	Micronutrient Fertilizer Rate lbs/a
Boron	
0 - 0.5	2
0.5 - 1.0	1
>1.0	0
Copper	
0 - 0.5	2
>0.5	0
Iron	
0 - 2.5	4
2.5 - 5.0	2
>5.0	0
Manganese	
0 - 0.50	20
0.50 - 1.0	10
>1.0	0
Zinc	
0 - 0.25	10
0.25 - 0.50	5
>0.50	0

*Based on soil sample from 0-6 inches. Montana research has shown that micronutrient levels may increase with soil depth, regardless of the soil analysis obtained from the top six inches of the profile.

Table 21. Estimated nutrient uptake in harvested portions of crops.*

Crop	Unit	Test Weight lbs/bu	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Zn	Mn	Cu	B
			----------lbs----------										
Alfalfa	ton		48	11	53	28	5	5.50	0.38	0.11	0.11	0.02	0.02
Barley-grain	bu	48	0.87	0.36	0.25	0.025	0.05	0.08		0.0015	0.0008	0.0008	0.001
Barley-straw	ton		14	4.10	30	7.6	2	3.8		0.045	0.30	0.01	
Bean	bu	60	3	0.79	0.92	0.18	0.06	0.52	.03	0.004	0.002	0.0015	0.003
Buckwheat	bu	48	0.86	0.16	0.22								
Canola/Mustard/ Rapeseed	bu	50-60	1.94	1.17	0.60			0.34					
Corn - grain	bu	56	0.73	0.60	0.27	0.015	0.05	0.07	0.0055	0.001	0.0006	0.0004	
Corn - straw	ton		19.8	8.8	40	5.8	4.50	3.20		0.067	0.33	0.01	
Flax	bu	56	2.12	0.85	0.75			0.21					
Grass	ton	13-45	25	10	38	7	2.50	2		0.08	0.13	0.01	
Lentil/Chickpea/ Pea	bu	60-68	2.18	0.67	0.87			0.15					
Millet/Canary Seed/Sorghum	bu	40-56	0.83	0.42	0.25	0.07	0.08	0.08		0.007	0.007	0.0002	

Oat - grain	bu	32	0.60	0.24	0.17	0.024	0.04	0.06		0.0006	0.001	0.0004	
Oat - straw	ton		12.2	5.80	33	0.40	4.00	4.60		0.145		0.015	
Potato	bu	50-60	0.20	0.13	0.38	0.009	0.02	0.38	0.16	0.0001	0.0002	0.0001	0.0001
Safflower	lbs	45	0.05	0.0125	0.038								
Soybean	bu	60	1.35	0.30	0.75	0.60	0.27	0.15		0.0002	0.0007	0.006	
Sugarbeet - root	ton		3.60	1.50	5.40	1.75	0.95	0.45			0.05	0.002	
Sugarbeet - top	ton		9.30	6.70	19.6	0.15	1.10	0.40			0.033	0.001	
Sunflower	bu	28	1.06	0.32	0.24		0.10	0.08					
Wheat - grain	bu	60	1.25	0.62	0.38	0.025	0.15	0.08		0.0035	0.002	0.0008	0.001
Wheat - straw	ton		14.5	3.60	25	4.4	2.20	3.7		0.03	0.11	0.007	

*Average of multiple published sources.