value crops such as tomatoes, peppers, blueberries, raspberries, strawberries, apples, vine crops, and cole crops.

As with overhead irrigation, nitrogen is the primary nutrient applied through the system. Nitrogen solutions are the most economical source of nitrogen to apply; potassium nitrate and ammonium sulfate are soluble and can also be used. Calcium nitrate is also water soluble but may precipitate if injected in high pH water. Drip irrigation, in combination with plastic mulch, allows for precise timing (spoon feeding) of nitrogen. Small amounts can be applied daily (1-2 lb N/A) or weekly (5-10 lb N/A) to meet the growth demands of the crop.

Potassium can also be injected without any precipitation problems, although in most Minnesota soils a broadcast and starter application can meet plant requirements. Phosphorus may precipitate with micronutrients or with calcium and magnesium in the irrigation water, resulting in clogging problems. Some micronutrients such as copper, iron, manganese, and zinc may also precipitate in high pH water. For most situations, phosphorus, and micronutrients, if needed, should be applied before planting. These elements can be injected alone in the drip system without precipitation problems. For phosphorus applications, phosphoric acid should be used. For micronutrients, chelated forms should be used. Clogging problems in drip lines can be corrected by injecting acids into the line to dissolve precipitates. If clogging is caused by bacteria or algae growth, then chlorine should be mixed with water. In all cases, the cause of clogging should be determined before treatment, and injection rates of chlorine or acid should be carefully monitored to avoid damaging the plants.

Calibration of fertilizer injection for drip irrigation is similar to that of a solid set sprinkler system in that a batch type injection is used. The area to be fertilized is first calculated and then the amount of fertilizer needed for that area is determined. In most cases, nutrients should be injected over a 15-20 minute period followed by a 15-20 minute flushing period.

Foliar Fertilization

For all fruit and vegetable crops, the major pathway for mineral nutrient uptake is via the roots. Nutrients applied to the leaves can be absorbed and utilized by the plant; however, for nitrogen, phosphorus, and potassium the quantity absorbed at any one time is small relative to the larger levels required for growth by the plant. Foliar application of these three nutrients cannot be expected to supply the total amount required for crop production.

An appropriate time to consider foliar fertilization would be when a shortage of a nutrient is evident as indicated by tissue analysis or visual symptoms. In these situations, foliar fertilization provides the quickest means to correct the problem. Certain soil conditions, such as high pH, excess moisture, or cool temperatures, may render a nutrient or nutrients unavailable to the plant root. If these conditions exist, the problem may be more effectively corrected by foliar applications compared with soil applications. For the macronutrients, foliar applications are a short-term solution. Refer to the potassium section **(page 15)** for suggestions on using potassium foliar sprays and **page 26** for using magnesium foliar sprays. Some crops have inefficient mechanisms for translocating calcium to fruits of young tissue. See the calcium section **(page 26)** for recommendations on using calcium foliar applications. For micronutrients, two to three applications may be all that are needed to meet crop demands. Even for micronutrients, the application is only effective during the year of application. Recommendations for rates of micronutrient foliar fertilizers to apply are provided in the micronutrient section **(pages 26-29)**.

Routine use of foliar fertilizers without a documented need is not recommended. Furthermore, foliar fertilization should not be used as a substitute for good soil fertility management. Have your soil tested and fertilize according to soil test recommendations.

Selecting a Yield Goal

Higher yielding crops generally require more nutrients than low yielding crops. For most fruit and vegetable crops listed in this bulletin, fertilizer recommendations are based on the yield obtained under optimum field conditions (i.e., water is not limiting and soil drainage is not a problem). If certain management practices such as plastic mulches, drip irrigation, row covers, or high tunnels are used, yield potential may be substantially higher than that reported in this bulletin. In those cases, an increase in fertilizer rates over those recommended may be warranted.

For the major processing crops (peas, sweet corn, snap beans, lima beans, and potatoes) where larger acreage is planted and soil conditions and water availability may not be as favorable as for the higher value fruit and vegetable crops, yield may vary as a function of the area in which the crop is grown as well as management practices. Selecting a realistic yield goal for these crops will improve fertilizer use efficiency. Reasonable yield goals are usually set at 15-20 percent higher than a grower's average yield for the past 5 years.

Primary Macronutrients

Nitrogen, phosphorus, and potassium are often referred to as the primary macronutrients because of the general probability of plants being deficient in these nutrients and the large quantities taken up from the soil relative to other essential nutrients.

Nitrogen

Of all the essential nutrients, nitrogen is the one most often limiting for crop growth. Many soils contain large amounts of nitrogen, but most of the nitrogen is tied up in the organic fraction and only slowly released. For most nonlegume crops, some nitrogen fertilizer is required for adequate yields. Nitrogen is available to the plant in two forms—ammonium (NH_4^+) and nitrate (NO_3^-). In most soils, ammonium is quickly converted to the nitrate form, a process called nitrification. This nitrate form is not tightly held on soil particles and is soluble in water. Consequently, nitrogen management is important both from a production and environmental standpoint. On sandy soils, nitrogen applied early in the season can be easily leached out of the root zone with heavy rainfall or excess irrigation. Nitrogen deficiency may result, as well as an increased potential for nitrate contamination of the groundwater. On irrigated sandy soils, nitrogen should be split applied—a small portion at planting and the remainder during the growing season after the

crop has become established. The need for split applications on fine-textured or organic soils is not as critical as on irrigated sandy soils. In fine-textured clay soils, heavy rainfall may saturate the soil causing nitrogen to be converted to a gas and lost to the atmosphere, a process called denitrification.

Because of the mobility of nitrate in soils and the complex transformations from organic matter, soil tests for nitrogen are not reliable for predicting nitrogen fertilizer needs in the eastern half of Minnesota, particularly on sandy irrigated soils. The rate of nitrogen to apply, therefore, is based on yield goal, soil organic matter content, and previous crop.

The organic matter of the soil can be classified into categories for use in making fertilizer recommendations. The categories are: **Low** for soils with O.M. less than 3.1%, **medium** for soils with O.M. between 3.1% and 4.5%, **high** for soils with O.M. greater than 4.5%. The very high category is used for peats and mucks with O.M. greater than 19%.

The recommendations provided should be used as a general guide. For some crops, response to nitrogen will depend on the cultivar. In many cases too much nitrogen applied will result in excessive vegetative growth at the expense of fruit growth. Certain cultivars of tomato, potato, and many of the vine crops are susceptible to producing excessive vegetative growth with too much applied nitrogen. Nitrogen recommendations for organic soils are much lower due to the continual release of nitrogen from the organic matter during the growing season. For all crops except potatoes, sweet corn, peas, lima beans, and snap beans, only one yield goal is assumed. In western Minnesota, where rainfall is limited, the nitrate test is useful for determining initial levels of soil nitrogen. Research in western Minnesota has shown that more accurate nitrogen recommendations can be made for many crops (particularly potatoes) by determining the nitrate-nitrogen content in the top 2 feet of soil. Use of the nitrate test is strongly recommended for crops grown in the western part of the state **(Figure 2)**. Refer to **Table 18** for potatoes and **Table 25** for sweet corn to determine nitrogen recommendations based on a nitrate test. For other vegetable crops, refer to **Table 28**. For fruit crops refer to **Tables 31** and **32**. Use the following formula:

$$\mathbf{Fert_N = N\ Rec_{low\ O.M.} - Soil_{N\ 0\text{-}2\ ft}}$$ **where:**

$Fert_N$ = Fertilizer N to Apply

$N\ Rec_{low\ O.M.}$ = N Recommendation at Low Organic Matter

$Soil_{N\ 0\text{-}2\ ft}$ = Soil Test Nitrate (0-2 feet)

As an example, if the nitrate test for the top 2 feet was 70 lb/A and carrots are to be planted, then the amount of fertilizer N to apply would be: 120 lb N/A - 70 lb N/A = 50 lb N/A.

In other areas of the state, nitrate tests will be run for those who desire it for monitoring purposes, but the results will not be used for making the nitrogen fertilizer recommendations. The nitrate soil test is not recommended for use on sandy soils.

Phosphorus

Phosphorus forms very insoluble complexes with aluminum and iron at low pH and calcium at high pH. Consequently, movement of phosphorus in soils is very low. For this reason, it is important to incorporate phosphate fertilizer into the soil rather than topdress. The form available to the plant is the

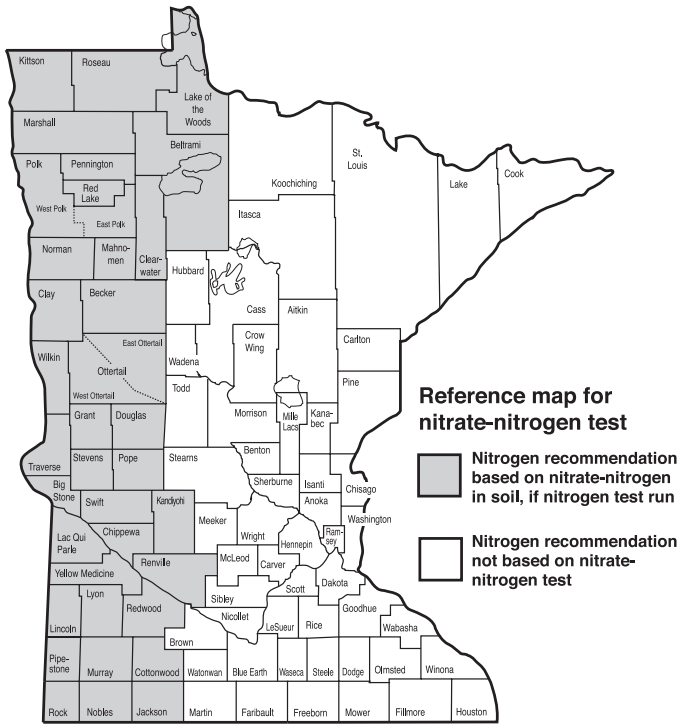

Figure 2. *Reference map for using the soil nitrate test.*

orthophosphate anion ($H_2PO_4^-$). Two different soil tests are used to determine available soil phosphorus. The Bray-P1 test is used when the soil pH is 7.4 or less and the Olsen-P test is used when the soil pH is greater than 7.4. It is important to note that interpretations for phosphorus fertilizer will change depending on which test is used. In other words, the extractable phosphorus using the Bray-P1 test is not equivalent to extractable phosphorus using the Olsen-P test.

Interpretations for relative phosphorus levels based on a soil test are presented in **Table 8** for lima beans, peas, snap beans, and sweet corn. Relative phosphorus levels for all other vegetable crops and fruit crops are presented in **Table 9**. The phosphorus measured does not represent all of the phosphorus that may be available for plant growth; i.e., some fraction of the organic phosphorus not measured may become available upon mineralization.

Response to phosphorus is most likely on low phosphorus testing soils and in the spring when soils are cool. Phosphorus recommendations are based on soil test phosphorus level, crop to be grown, and, for some crops, yield goal. For most seeded vegetable crops, banding a portion of the recommended phosphorus fertilizer 2-3 inches from the seed at planting will enhance root growth in cool soils in the spring compared with broadcast phosphorus. For high testing phosphorus soils, only banded phosphorus fertilizer is needed. For low phosphorus testing soils, a portion of the phosphorus fertilizer should be broadcast and incorporated.

Phosphorus is the primary nutrient associated with algal blooms in surface waters. Phosphorus can enter surface waters by runoff and wind erosion of soil particles. Runoff of phosphorus from decaying plant material and animal manure can also contribute to the problem. For these reasons it is important not to use excessive rates of manure or phosphorus fertilizers on sites vulnerable to runoff and erosion.

Table 8. *Relative soil test levels of phosphorus for lima beans, peas, snap beans, and sweet corn.*

Relative Level	Bray-P1	Olsen-P
	ppm	ppm
Low	0-5	0-3
Medium	6-10	4-7
Medium-high	11-15	8-11
High	16-20	12-15
Very high	21+	16+

Table 9. *Relative soil test levels of phosphorus for fruit and vegetable crops not listed in Table 8.*

Relative Level	Bray-P1	Olsen-P
	ppm	ppm
Low	0-10	0-7
Medium	11-20	8-15
Medium-high	21-30	16-25
High	31-40	26-33
Very high	41+	34+

Starter solutions high in phosphate are recommended for fruit and vegetable transplants to promote root growth. Follow the manufacturer's recommendations for the amount of fertilizer to mix with water. Typically, a high phosphate analysis starter solution such as 10-52-17 should be mixed at the rate of 3 pounds of material per 50 gallons of water. This solution should be applied at a rate of about $^1/_2$ pint per plant.

Potassium

Potassium is available to plants as the K^+ ion. Movement of potassium in soils is dependent on soil texture. As the clay content increases, movement of potassium decreases. For most soils, it is important that applied potassium be incorporated into the soil rather than topdressed. In sandy soils, potassium can actually leach out of the root zone. Consequently, sandy soils tend to be low in available potassium. As with phosphorus, a portion of the potassium can be banded 2-3 inches from the seed at planting. For high potassium testing soils, only banded potassium fertilizer application is necessary. For low testing potassium soils at least half of the potassium fertilizer should be broadcast. Interpretation for relative levels of potassium based on a soil test are presented in **Table 10**. Excessive magnesium fertilization can induce a potassium deficiency. Recommendations for fertilizer potassium are based on relative soil test level, crop to be grown, and, for some crops, yield goal. The most common source of potash fertilizer used for crop production is potassium chloride (0-0-60). Sulfate sources are also available, but the cost is higher. If sulfur or magnesium is also needed, potassium magnesium sulfate is the suggested fertilizer to use.

For apples grown in Minnesota, potassium deficiency is a common problem. While soil potash application is the preferred long-term solution to correct potassium deficiency, foliar application may be used to correct potassium deficiency during the season. Foliar sprays of potassium nitrate or sulfate at 6 to 10 lb per 100 gallons of water (200 gallons per acre) are suggested as a temporary measure to correct the problem.

Table 10. *Relative soil test levels of potassium for fruit and vegetable crops.*

Relative Level	K
	ppm
Low	0-40
Medium	41-80
Medium-high	81-120
High	121-160
Very high	161+

Lima Beans

Table 11. *Nitrogen recommendations for lima beans.*

Yield Goal	Previous Crop and Organic Matter (O.M.) Level							
	alfalfa (good stand) - O.M. -[2]		soybeans field peas - O.M. -		any crop in Group 1[1] - O.M. -		any crop in Group 2[1] - O.M.-	
	low[3]	medium to high	low	medium to high	low	medium to high	low	medium to high
lb/A	N to apply (lb/A)							
less than 2000	0	0	0	0	0	0	0	0
2000 - 2900	0	0	0	0	0	0	10	0
3000 - 3900	0	0	10	0	0	0	20	10
4000 - 4900	0	0	20	10	10	0	40	20
5000 or more	0	0	40	20	20	0	60	40

[1] Crops in Group 1		[1]Crops in Group 2	
alfalfa (poor stand[4] or new seeding)	barley	grass-hay	sorghum-sudan
alsike clover or red clover	buckwheat	grass-pasture	sugarbeets
birdsfoot trefoil	canola	millet	sunflowers
fallow	corn	mustard	sweet corn
grass-legume hay	edible beans	oats	triticale
grass-legume pasture	flax	potatoes	wheat
		rye	vegetables

[2] *Low = less than 3.1% O.M., medium to high = 3.1-19% O.M.*

[3] *The well-drained silt loam soils in southeastern Minnesota with low O.M. receive the same N recommendation for soils with a medium to high O.M. content.*

[4] *Poor stand is less than 4 crowns per sq. ft.*

Table 12. *Phosphate recommendations for lima beans.*

Yield Goal	Soil Test P (ppm)				
Bray-P1	0-5	6-10	11-15	16-20	21+
Olsen-P	0-3	4-7	8-11	12-15	16+
lb/A	P_2O_5 to apply (lb/A)				
less than 2000	25	15	0	0	0
2000 - 2900	50	25	15	0	0
3000 - 3900	75	50	25	15	0
4000 - 4900	100	75	50	25	0
5000 or more	125	100	75	50	0

Table 13. *Potash recommendations for lima beans.*

Yield Goal	Soil Test K (ppm)				
	0-40	41-80	81-120	121-160	161+
lb/A	K_2O to apply (lb/A)				
less than 2000	25	15	0	0	0
2000 - 2900	50	25	15	0	0
3000 - 3900	75	50	25	15	0
4000 - 4900	100	75	50	25	0
5000 or more	125	100	75	50	0

Peas

Table 14. *Nitrogen recommendations for peas.*

Yield Goal	Previous Crop and Organic Matter (O.M.) Level							
	alfalfa (good stand) - O.M. -[2]		soybeans field peas - O.M. -		any crop in Group 1[1] - O.M. -		any crop in Group 2[1] - O.M. -	
	low[3]	medium to high	low	medium to high	low	medium to high	low	medium to high
lb/A	N to apply (lb/A)							
less than 1000	0	0	0	0	0	0	0	0
1000 - 1900	0	0	0	0	0	0	10	0
2000 - 3900	0	0	10	0	0	0	20	10
4000 or more	0	0	20	0	10	0	40	20

[1]Crops in Group 1	[1]Crops in Group 2		
alfalfa (poor stand[4] or new seeding)	barley	grass-hay	sorghum-sudan
alsike clover or red clover	buckwheat	grass-pasture	sugarbeets
birdsfoot trefoil	canola	millet	sunflowers
fallow	corn	mustard	sweet corn
grass-legume hay	edible beans	oats	triticale
grass-legume pasture	flax	potatoes	wheat
		rye	vegetables

[2] *Low = less than 3.1% O.M., medium to high = 3.1-19% O.M.*

[3] *The well-drained silt loam soils in southeastern Minnesota with low O.M. receive the same N recommendation for soils with medium to high O.M. content.*

[4] *Poor stand is less than 4 crowns per sq. ft.*

Table 15. *Phosphate recommendations for peas.*

Yield Goal	Bray-P1 / Olsen-P	Soil Test P (ppm)				
		0-5 / 0-3	6-10 / 4-7	11-15 / 8-11	16-20 / 12-15	21+ / 16+
lb/A		P_2O_5 to apply (lb/A)				
less than 1000		25	15	0	0	0
1000 - 1900		50	25	15	0	0
2000 - 3900		75	50	25	15	0
4000 or more		100	75	50	25	0

Table 16. *Potash recommendations for peas.*

Yield Goal	Soil Test K (ppm)				
	0-40	41-80	81-120	121-160	161+
lb/A	K_2O to apply (lb/A)				
less than 1000	25	15	0	0	0
1000 - 1900	50	25	15	0	0
2000 - 3900	75	50	25	15	0
4000 or more	100	75	50	25	0

Potatoes

Table 17. *Nitrogen recommendations for potatoes when the soil nitrate test is not used.*

	Previous Crop and Organic Matter (O.M.) Level								
	alfalfa (good stand) - O.M. -[2]		soybeans field peas - O.M. -		any crop in Group 1[1] - O.M. -		any crop in Group 2[1] - O.M. -		
Yield Goal	low[4]	medium to high	low	medium to high	low	medium to high	low	medium to high	Organic Soil[3]
cwt/A	N to apply (lb/A)[5]								
less than 200	0	0	55	35	35	15	75	55	0
200 - 249	0	0	80	60	60	40	100	80	0
250 - 299	25	0	105	85	85	65	125	105	30
300 - 349	50	30	130	110	110	90	150	130	30
350 - 399	75	55	155	135	135	115	175	155	30
400 - 449	100	80	180	160	160	140	200	180	40
450 - 499	125	105	205	185	185	165	225	205	40
500 or more	150	130	230	210	210	190	250	230	50

[1]Crops in Group 1	[1]Crops in Group 2		
alfalfa (poor stand[6] or new seeding)	barley	grass-hay	sorghum-sudan
alsike clover or red clover	buckwheat	grass-pasture	sugarbeets
birdsfoot trefoil	canola	millet	sunflowers
fallow	corn	mustard	sweet corn
grass-legume hay	edible beans	oats	triticale
grass-legume pasture	flax	potatoes	wheat
		rye	vegetables

[2] *Low = less than 3.1% O.M., medium to high = 3.1-19% O.M.*
[3] *Organic soil = more than 19% O.M.*
[4] *The well-drained silt loam soils in southeastern Minnesota with low O.M. receive the same N recommendation for soils with a medium to high O.M. content.*
[5] *For irrigated sandy soils, split N applications are recommended: 1/5 at planting, 2/5 at emergence, and 2/5 at hilling. Application of nitrogen after hilling should be based on petiole analysis (refer to the section on tissue/petiole analysis, page 35).*
[6] *Poor stand is less than 4 crowns per sq. ft.*

Table 18. *Nitrogen recommendations for potatoes when the soil nitrate test is used.*

Yield Goal	Soil Nitrate-N (0-2 ft) + fertilizer N
cwt/A	lb/A
less than 200	60
200 - 249	80
250 - 299	100
300 - 349	120
350 - 399	140
400 - 450	160
451 or more	200

Table 19. *Phosphate recommendations for potatoes.[1]*

		Soil Test P Level (ppm)							
Yield Goal	Bray-P1 Olsen-P	0-5 0-3	6-10 4-7	11-15 8-11	16-20 12-15	21-25 16-18	26-30 19-22	31-50 23-41	51+ 42+
cwt/A		$-P_2O_5$ to apply (lb/A)[2]							
less than 200		75	50	25	0	0	0	0	0
200 - 299		100	75	50	25	0	0	0	0
300 - 399		125	100	75	50	50	50	50	50
400 - 499		150	125	100	75	75	75	75	75
500 or more		175	150	125	100	100	100	100	75

[1] *For acid irrigated sands, responses up to 150 lb/A P_2O_5 have been observed on very high (41+ ppm) P soils.*
[2] *For most efficient application, apply phosphate fertilizer in a band 2-3 inches below and to each side of the tuber planting.*

Table 20. *Potash recommendations for potatoes.*

	Soil Test K Level (ppm)					
Yield Goal	**0-40**	**40-80**	**81-120**	**121-160**	**161-200**	**201+**
cwt/A	- K_2O to apply (lb/A)[1] -					
less than 200	150	75	50	25	0	0
200 - 299	200	100	75	50	25	20
300 - 399	300	200	100	75	50	25
400 - 499	400	300	200	100	75	50
500 or more	500	400	300	150	100	75

[1] *Do not apply more than 200 lb K_2O/A in the band at planting.*

Snap Beans

Table 21. *Nitrogen recommendations for snap beans.*

	Previous Crop and Organic Matter (O.M.) Level							
	alfalfa (good stand) - O.M. -[2]		**soybeans field peas - O.M. -**		**any crop in Group 1[1] - O.M. -**		**any crop in Group 2[1] - O.M. -**	
Yield Goal	**low[3]**	**medium to high**	**low**	**medium to high**	**low**	**medium to high**	**low**	**medium to high**
lb/A	- N to apply (lb/A) -							
less than 3000	0	0	0	0	0	0	0	0
3000 - 4900	0	0	0	0	0	0	10	0
5000 - 6900	0	0	10	0	0	0	20	10
7000 - 8900	0	0	20	10	10	0	40	20
9000 or more	0	0	40	20	20	0	60	40

[1]Crops in Group 1
alfalfa (poor stand[4] or new seeding)
alsike clover or red clover
birdsfoot trefoil
fallow
grass-legume hay
grass-legume pasture

[1]Crops in Group 2			
barley	grass-hay	sorghum-sudan	
buckwheat	grass-pasture	sugarbeets	
canola	millet	sunflowers	
corn	mustard	sweet corn	
edible beans	oats	triticale	
flax	potatoes	wheat	
	rye	vegetables	

[2] *Low = less than 3.1% O.M., medium to high = 3.1-19% O.M.*

[3] *The well-drained silt loam soils in southeastern Minnesota with low O.M. receive the same N recommendation for soils with a medium to high O.M. content.*

[4] *Poor stand is less than 4 crowns per sq. ft.*

Table 22. *Phosphate recommendations for snap beans.*

		Soil Test P (ppm)				
Yield Goal	**Bray-P1**	**0-5**	**6-10**	**11-15**	**16-20**	**21+**
	Olsen-P	**0-3**	**4-7**	**8-11**	**12-15**	**16+**
lb/A		- P_2O_5 to apply (lb/A) -				
less than 3000		50	25	0	0	0
3000 - 4900		50	25	25	0	0
5000 - 6900		75	50	25	25	0
7000 - 8900		100	75	50	25	0
9000 or more		125	100	75	50	0

Table 23. *Potassium recommendations for snap beans.*

	Soil Test K (ppm)				
Yield Goal	**0-40**	**41-80**	**81-120**	**121-160**	**161+**
lb/A	- K_2O to apply (lb/A) -				
less than 3000	25	25	0	0	0
3000 - 4900	50	25	25	0	0
5000 - 6900	75	50	25	25	0
7000 - 8900	100	75	50	25	0
9000 or more	150	100	75	50	0

Sweet Corn

Table 24. *Nitrogen recommendations for sweet corn.*

Yield Goal	Previous Crop and Organic Matter (O.M.) Level								
	alfalfa (good stand) - O.M. -[2]		soybeans field peas - O.M. -		any crop in group 1[1] - O.M. -		any crop in group 2[1] - O.M. -		Organic Soil[3]
	low[4]	medium to high	low	medium to high	low	medium to high	low	medium to high	
tons/A	N to apply (lb/A)[5]								
less than 6	10	0	80	50	70	40	110	80	10
6 - 7	30	0	100	70	90	60	130	100	30
8 - 9	50	20	120	90	110	80	150	120	50
10 or more	70	40	140	110	130	100	170	140	70

[1]Crops in Group 1		[1]Crops in Group 2	
alfalfa (poor stand[6] or new seeding)	barley	grass-hay	sorghum-sudan
alsike clover or red clover	buckwheat	grass-pasture	sugarbeets
birdsfoot trefoil	canola	millet	sunflowers
fallow	corn	mustard	sweet corn
grass-legume hay	edible beans	oats	triticale
grass-legume pasture	flax	potatoes	wheat
		rye	vegetables

[2] *Low = less than 3.1% O.M. , medium to high = 3.1-19% O.M.*

[3] *Organic soil = more than 19% O.M.*

[4] *The well-drained silt loam soils in southeastern Minnesota with low O.M. receive the same N recommendation for soils with a medium to high O.M. content. All irrigated soils are included in the low O.M. category.*

[5] *For irrigated sandy soils, split N applications are recommended: 10-20 lb N/A in the starter and the remainder in one or two more applications at the 4-6 leaf stage and the 10-12 leaf stage.*

[6] *Poor stand is less than 4 crowns per sq. ft.*

Table 25. *Nitrogen recommendations for sweet corn when the soil nitrate test is used.*

Yield Goal	Soil Nitrate-N (0-2 ft) + fertilizer N
cwt/A	lb N/A
less than 6	70
6-7	110
8-9	145
10 or more	180

Table 26. *Phosphate recommendations for sweet corn production.*

Yield Goal	Bray-P1 Olsen-P	Soil Test P (ppm)									
		0-5 0-3		6-10 4-7		11-15 8-11		16-20 12-15		21+ 16+	
		Bcst or Row		Bcst or Row		Bcst or Row		Bcst or Row		Bcst or Row	
tons/A		P_2O_5 to apply (lb/A)									
less than 6		70	40	40	25	30	20	10	10-15	0	10-15
6 - 7		80	40	50	30	30	20	10	10-15	0	10-15
8 - 9		90	40	60	35	40	25	10	10-15	0	10-15
10 or more		100	40	70	40	40	25	20	10-15	0	10-15

Table 27. *Potassium recommendations for sweet corn production.*

Yield Goal	Soil Test K (ppm)									
	0-40		41-80		81-120		121-160		161+	
	Bcst or Row		Bcst or Row		Bcst or Row		Bcst or Row		Bcst or Row	
tons/A	K_2O to apply (lb/A)									
less than 6	120	40	60	30	40	10-15	40	10-15	0	10-15
6-7	140	40	80	30	40	10-15	40	10-15	0	10-15
8-9	160	40	100	40	60	25	40	10-15	0	10-15
10 or more	180	40	120	40	80	30	60	25	0	10-15

Vegetable Crops

Table 28. *Nitrogen recommendations for vegetable crops.*

Crop	Approximate Yield Goal[2]	Soil Organic Matter Level (O.M.)[1] Low	Medium	High	Organic Soil	Suggested Method of Application[3,4,5]
	cwt/A	----------N to apply (lb/A)----------				
Asparagus (New Planting)	—	120	100	80	50	1/3 broadcast, 2/3 sidedress during cultivation
Asparagus (Est. Planting)	40	80	60	40	20	topdress before cutting starts or after harvest
Beets, table	200	100	80	60	30	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Broccoli	120	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Brussels sprouts	175	140	120	100	70	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Cabbage	400	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Carrots	400	120	100	80	50	1/2 broadcast, 1/2 sidedress when plants are established
Cauliflower	150	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Celery	600	180	160	140	100	1/3 bcst, 1/3 sidedress 2 wks after planting, 1/3 sidedress 5 wks after planting
Cucumber	250	100	80	60	30	1/2 broadcast, 1/2 sidedress when vines begin to run
Eggplant	250	120	100	80	50	1/2 broadcast, 1/2 sidedress when fruit appear
Endive	180	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Garlic	150	120	100	80	50	1/3 broadcast at planting (Sept./Oct.), 2/3 sidedress when shoots emerge in spring
Lettuce	300	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Mint	—	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Muskmelon	200	100	80	60	30	1/2 broadcast, 1/2 sidedress when vines begin to run
Onions (dry)	500	130	110	90	60	1/4 banded, 3/4 sidedress 4-5 wks after emergence
Onions (green)	150	80	60	40	20	1/4 bcst, 1/2 sidedress 4-5 wks after emergence, 1/4 sidedress 4 wks before hvst
Parsley	—	100	80	60	30	1/2 broadcast, 1/4 after first cutting, 1/4 after 2nd cutting
Parsnips	400	120	100	80	50	1/2 broadcast, 1/2 sidedress after plants are established
Peppers	200	140	120	100	70	1/2 broadcast, 1/2 sidedress after fruit appear
Pumpkins	400	70	50	30	20	1/2 broadcast, 1/2 sidedress after vines begin to run
Radishes	70	50	40	30	20	broadcast
Rhubarb (New Planting)	—	100	80	60	30	1/2 broadcast, 1/2 sidedress after plants are established
Rhubarb (Est. Planting)	200	80	60	40	20	1/2 broadcast in spring, 1/2 sidedress after last cutting
Rutabagas	400	100	80	60	30	1/2 broadcast, 1/2 sidedress when plants are 4-6 inches tall
Spinach	150	100	80	60	30	1/2 broadcast, 1/2 sidedress 4-5 weeks after planting
Squash	300	70	50	30	20	1/2 broadcast, 1/2 sidedress after vines begin to run
Swiss Chard	150	120	100	80	50	1/2 broadcast, 1/2 sidedress 3-5 wks after planting
Tomatoes	270	130	110	90	60	1/2 broadcast, 1/2 sidedress when fruit appear
Turnips	300	60	50	40	20	broadcast
Watermelon	300	100	80	60	30	1/2 broadcast, 1/2 sidedress when vines begin to run

[1] *Low = less than 3.1% O.M., medium = 3.1-4.5% O.M., high = 4.6-19% O.M., Organic soil = greater than 19% O.M.*

[2] *Recommendations are based on attaining approximate yield goals listed.*

[3] *Suggested methods of application are a general guide and can be modified when appropriate.*

[4] *On sandy soils, sidedress applications may be split 1-2 more times (not to exceed total recommended unless a need is indicated).*

[5] *Up to 30 lb N/A of the broadcast application can be banded if equipment is available.*

Nitrogen credits for previous crops:

Alfalfa (good stand)	:	70 lb N/A
Alfalfa (poor stand) Alsike clover Birdsfoot trefoil Grass-legume hay Grass-legume pasture Red clover	:	40 lb N/A
Snap beans Peas Soybeans	:	20 lb N/A
All other crops	:	0 lb N/A

Table 29. *Phosphorus recommendations for vegetable crops.*

Crop	Approximate Yield Goal[1]	Bray-P1 Olsen-P	Soil Test P Level (ppm) 0-10 0-7	11-20 8-15	21-30 16-25	31-40 26-33	41-50 34-41	51+ 42+
	cwt/A		- P_2O_5 to apply (lb/A)[2] - - - - - - - - - - - - - - - - - -					
Asparagus (New Planting)	—		200	150	100	50	25	25
Asparagus (Est. Planting)	40		75	50	25	0	0	0
Beets, table	200		150	100	75	50	25	0
Broccoli	120		150	100	75	50	25	0
Brussels Sprouts	175		150	100	75	50	25	0
Cabbage	400		150	100	75	50	25	0
Carrots	400		150	100	75	50	25	0
Cauliflower	150		150	100	75	50	25	0
Celery	600		200	150	100	50	25	0
Cucumber	250		150	100	75	50	25	0
Eggplant	250		150	100	75	50	25	0
Endive	180		150	100	75	50	25	0
Garlic	150		150	100	75	50	25	0
Lettuce	300		150	100	75	50	25	0
Mint	—		150	100	75	50	25	0
Muskmelon	200		150	100	75	50	25	0
Onions (dry)	500		200	100	100	50	25	0
Onions (green)	150		150	100	75	50	25	0
Parsley	—		100	100	75	50	25	0
Parsnips	400		150	100	75	50	25	0
Peppers	200		150	100	75	50	25	0
Pumpkins	400		150	100	75	50	25	0
Radishes	70		100	75	50	25	0	0
Rhubarb (New Planting)	—		200	150	100	50	25	25
Rhubarb (Est. Planting)	200		75	50	25	0	0	0
Rutabagas	400		150	100	75	50	25	0
Spinach	150		150	100	75	50	25	0
Squash	300		150	100	75	50	25	0
Swiss Chard	150		150	100	75	50	25	0
Tomatoes	270		150	100	75	50	25	0
Turnips	300		100	75	50	25	0	0
Watermelon	300		150	100	75	50	25	0

[1] *Recommendations are based on attaining approximate yield goals listed.*
[2] *Recommended rates are for total amount to apply: broadcast + starter. Up to 70 lb P_2O_5 can be banded at planting.*

Table 30. *Potassium recommendations for vegetable crops.*

Crop	Approximate Yield Goal[1]	Soil Test K Level (ppm)					
		0-40	41-80	81-120	121-160	161-200	201+
	cwt/A	K_2O to apply (lb/A)[2]					
Asparagus (New Planting)	—	250	200	150	100	50	0
Asparagus (Est. Planting)	40	100	75	50	25	0	0
Beets, table	200	200	150	100	75	50	0
Broccoli	120	250	200	150	100	50	0
Brussels Sprouts	175	250	200	150	100	50	0
Cabbage	400	250	200	150	100	50	0
Carrots	400	200	150	100	75	50	0
Cauliflower	150	250	200	150	100	50	0
Celery	600	250	200	150	100	50	0
Cucumber	250	200	150	100	75	50	0
Eggplant	250	200	150	100	75	50	0
Endive	180	200	150	100	75	50	0
Garlic	150	200	150	100	75	50	0
Lettuce	300	200	150	100	75	50	0
Mint	—	200	150	100	75	50	0
Muskmelon	200	200	150	100	75	50	0
Onions (dry)	500	250	200	150	100	50	0
Onions (green)	150	200	150	100	75	50	0
Parsley	—	200	150	100	75	50	0
Parsnips	400	200	150	100	75	50	0
Peppers	200	200	150	100	75	50	0
Pumpkins	400	200	150	100	75	50	0
Radishes	70	100	75	50	25	0	0
Rhubarb (New Planting)	—	250	200	150	100	50	0
Rhubarb (Est. Planting)	200	150	100	75	50	25	0
Rutabagas	400	200	150	100	75	50	0
Spinach	150	200	150	100	75	50	0
Squash	300	200	150	100	75	50	0
Swiss Chard	150	200	150	100	75	50	0
Tomatoes	270	250	200	150	100	50	0
Turnips	300	100	75	50	25	0	0
Watermelon	300	200	150	100	75	50	0

[1] *Recommendations are based on attaining approximate yield goals listed.*
[2] *Recommended rates are for total amount to apply: broadcast + starter. Up to 30 lb K_2O can be banded at planting.*

Fruit Crops

Table 31. *Nitrogen recommendations for fruit crops—new plantings.*

Crop	Soil Organic Matter (O.M.) Level[1] Low	Medium	High	Organic Soil	Suggested Method of Application[2,3]
	- - - - - - - - N to apply (lb/A) - - - - - - - - - - - - -				
Apples	60	45	30	20	1/2 broadcast, 1/2 sidedress in June
Blueberries	30	20	10	10	sidedress when 2nd flush of growth starts
Grapes	60	45	30	20	1/2 broadcast, 1/2 sidedress in June
Raspberries	60	50	40	25	1/2 broadcast, 1/2 sidedress in June
Strawberries	80	70	60	25	1/2 broadcast, 1/2 sidedress in August

[1] *Low = less than 3.1% O.M., medium = 3.1-4.5% O.M., high = 4.6-19% O.M., Organic soil = greater than 19% O.M.*
[2] *Suggested methods of application are a general guide and can be modified when appropriate.*
[3] *On sandy soils, sidedress applications may be split 1-2 more times (not to exceed total recommended unless a need is indicated).*

Nitrogen credits for previous crops:		
Alfalfa (good stand)	:	70 lb N/A
Alfalfa (poor stand) Alsike clover Birdsfoot trefoil Grass-legume hay Grass-legume pasture Red clover	:	40 lb/N/A
Snap beans Peas Soybeans	:	20 lb N/A
All other crops	:	0 lb N/A

Table 32. *Nitrogen recommendations for fruit crops—established plantings.*[1]

Crop	Approximate Yield Goal[3]	Soil Organic Matter (O.M.) Level[2] Low	Medium	High	Organic Soil	Suggested Method of Application[4,5]
	cwt/A	- - - - - - - - - -N to apply (lb/A)- - - - - - - - - -				
Apples	140	30	20	10	0	sidedress in spring
Blueberries	50	50	35	20	10	sidedress in spring
Grapes	60	30	20	10	0	sidedress in spring
Raspberries	40	60	50	40	20	sidedress in spring
Strawberries	100	80	70	60	25	topdress after renovation

[1] *Leaf analysis should also be used to help determine nitrogen needs (see page 32).*
[2] *Low = less than 3.1% O.M., medium = 3.1-4.5% O.M., high = 4.6-19% O.M., Organic soil = greater than 19% O.M.*
[3] *Recommendations are based on attaining approximate yield goals listed.*
[4] *Suggested methods of application are a general guide and can be modified when appropriate.*
[5] *On sandy soils, sidedress applications may be split 1-2 more times (not to exceed total recommended unless a need is indicated).*

Table 33. *Phosphorus recommendations for fruit crops—new plantings.*

Crop	Bray-P1 Olsen-P	Soil Test P Level (ppm) 0-10 0-7	11-20 8-15	21-30 16-25	31-40 26-33	41-50 34-41	51+ 42+
		- P_2O_5 to apply (lb/A) -					
Apples		150	125	100	75	50	25
Blueberries		100	75	50	25	0	0
Grapes		150	125	100	75	50	25
Raspberries		100	75	50	25	0	0
Strawberries		150	125	100	75	50	25

Table 34. *Phosphorus recommendations for fruit crops—established plantings.*[1]

Crop	Approximate Yield Goal	Bray-P1	Soil Test P Level (ppm) 0-10	11-20	21-30	31-40	41-50	51+
		Olsen-P	0-7	8-15	16-25	26-33	34-41	42+
	cwt/A		- - - - - - - - - - - - - - - - - - P_2O_5 to apply (lb/A) -
Apples	140		100	75	50	0	0	0
Blueberries	50		75	50	25	0	0	0
Grapes	60		100	75	50	0	0	0
Raspberries	40		75	50	25	0	0	0
Strawberries	100		100	50	25	0	0	0

[1] *Leaf analysis should also be used to help determine phosphorus needs (see page 32).*

Table 35. *Potassium recommendations for fruit crops—new plantings.*

Crop	Soil Test K Level (ppm) 0-40	41-80	81-120	121-160	161-200	201+
	- K_2O to apply (lb/A) -
Apples	300	250	200	100	50	0
Blueberries	200	150	100	50	25	0
Grapes	250	200	150	100	50	0
Raspberries	200	150	100	50	25	0
Strawberries	200	150	100	50	25	0

Table 36. *Potassium recommendations for fruit crops—established plantings.*[1]

Crop	Approximate Yield Goal	Soil Test K Level (ppm) 0-40	41-80	81-120	121-160	161-200	201+
	cwt/A	- K_2O to apply (lb/A)- -
Apples	140	200	150	100	50	0	0
Blueberries	50	150	100	50	25	0	0
Grapes	60	200	150	100	50	0	0
Raspberries	40	100	75	50	25	0	0
Strawberries	100	200	150	100	50	0	0

[1] *Leaf analysis should also be used to help determine potassium needs (see page 32).*