Field Crop Fertilizer Recommendations For Alaska Vegetables

Most cool-season vegetables can be successfully grown outdoors in Alaska. Many will benefit from cultural practices designed to lengthen the growing season. These include transplanting greenhouse-grown seedlings rather than seeding directly in the field, growing plants on plastic mulches and using plastic row covers. Most may be successfully produced by direct-seeding in bare soil; however, yields may be lower. The recommendations in this publication are general in nature and should apply regardless of the cultural practices used in vegetable production. Warm-season vegetables such as tomatoes and peppers may be reliably produced in much of Alaska only in a greenhouse. These crops are not included in this publication.

Relatively little fertility research has been conducted on vegetables in Alaska. Most previous Alaska research has been conducted on lettuce; the information provided for other vegetable crops is adapted from research and recommendations from other states.

Soil Acidity

The preferred soil pH ranges for vegetable crops are listed in Table 1. These ranges are for mineral soils only. Organic soils (peats and mucks) may be maintained at lower pH levels and are rarely limed. In mineral soils, the soil pH should be adjusted to approximately the middle of the recommended range for best performance. Various liming materials may be used to raise pH; elemental sulfur or aluminum sulfate may be used to reduce it.

Nitrogen source is not considered to be critical for most vegetables, as long as management is suitable for the chosen fertilizer source (for example, urea should be incorporated rather than applied to the soil surface). If organic sources of N are used, release rates must be rapid enough to provide adequate N for the growing plant.

Leguminous crops such as beans and peas can fix atmospheric N if they are inoculated with proper rhizobium

Table 1. Vegetable crop soil pH ranges.

Vegetable	Optimum pH range
Beets	5.8–8.0
Broccoli	6.0–7.5
Brussels sprouts	6.0–7.5
Cabbage	5.8–8.0
Carrots	5.3–6.8
Cauliflower	5.8–7.0
Celery	5.8–7.0
Chinese cabbage	6.0–7.5
Lettuce	5.8–7.0
Peas	5.8–6.8
Radishes	5.8–7.0
Squash	5.3–7.5
Turnips	6.0–7.0

Source: Western Fertilizer Handbook: Horticulture Edition by the Soil Improvement Committee, California Fertilizer Association.

Table 2. Recommended nitrogen application rates for vegetables in Alaska

Vegetable	lb/a
Beets	75–100
Broccoli	100–150
Cabbage	100–150
Carrots	60–100
Cauliflower	100–150
Celery	100–150
Cucumbers	75–100
Lettuce	100–125
Peas	25–50
Radishes	50
Squash	50–100

bacteria. Inoculum should be applied to legume seeds prior to planting unless the seed has been pre-inoculated. Follow supplier's recommendations for inoculum rate and handling procedures.

Phosphorus

Phosphorus (P) utilization is affected by soil conditions, including both the past fertilization history of the soil as reflected by the soil test P level and by soil minerology. Generally, soils testing high in P require a lower rate of fertilization than those with a low test level. Also, soils with high capacities for fixing or immobilizing phosphorus may require higher P application rates to overcome this fixing capacity. In non-alkaline soils, P immobilization increases as soil pH drops. Additionally, there are two types of soils in Alaska that have high P fixing capacity: the volcanic ash soils (including the Kachemak, Kashwitna, Naptowne, Rabideaux and Tustumena series) and the alkaline soils of Interior Alaska.

Phosphorus availability is also reduced in cold soils, which are usually found early in the growing season. Therefore, it is important to supply enough P to plants during this critical period. This may be achieved through application of starter fertilizer at the time of planting.

The recommended rates in Table 3 are based on the use of highly soluble P sources such as triple super phosphate, ordinary or single super phosphate, mono- or diammonium phosphates or similar materials. If materials with slowly available P, such as rock phosphates, or some other organic sources are used, application rates will generally have to be adjusted upward. The recommended application rates are for the soil test listed above each recommendation. All recommendations are in pounds of P_2O_5 per acre. For soil test values between those listed, interpolate from the values in Table 3. For example, a Kenai soil testing 20 ppm P (half-way between the very low and low categories) would require about 175 pounds of P_2O_5 per acre (half-way between 150 and 200).

Phosphorus fertilizers are usually applied at or before the time of planting. Phosphorus may be broadcast uniformly and incorporated into the soil or may be banded at planting. Fertilizer bands should not be in contact with the vegetable seed or seedling, but should be placed two inches below and two inches to the side of the seed or seedling. If fertilizer is banded, the rate of application may be adjusted slightly downward (decrease by no more than 25 percent).

Potassium

Both potassium chloride and potassium sulfate provide an adequate source of K for vegetables. Potassium chloride is generally less expensive, although potassium sulfate may be preferred for the fertilization of salt-sensitive crops or when salt-sensitive crops are included in a rotation (see Table 4).

Potassium may be applied prior to or at planting. Either band or broadcast applications of K should generally provide satisfactory results, although salt-sensitive crops may be adversely affected by banded fertilizers. High salt levels can burn root tissues, inhibit root growth and slow plant development. Follow the recommended K application rates in Table 5.

Secondary and Micronutrients

Deficiencies of secondary nutrients (calcium (Ca), magnesium (Mg) and sulfur (S)) are uncommon. They are most likely to occur on well-drained soils. Adequate S will almost always be provided if sulfate salts of potassium or nitrogen are used. Calcium and Mg levels usually will be adequate if the soil pH is maintained in the proper range. If secondary nutrients are found to be lacking, they may be broadcast or band applied before or at the time of planting according to Table 6. If the soil pH is too low, Ca can be supplied by applying calcitic lime, or Ca and Mg can be provided with application of dolomitic lime.

Micronutrient nutrition usually is not a problem in vegetable production. However, copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) may become deficient if the soil pH is high (pH of 7.0 or above). In this case the best remedy is to lower the soil pH by addition of elemental sulfur. If required, the micronutrients may be added at the rates suggested in Table 7 with the following exceptions. Beets, cauliflower and celery have very high boron (B) requirements; add one pound/acre every year when growing these crops. If B deficiency is suspected, soil and plant analyses are recommended. Also, molybdenum (Mo) deficiencies are fairly common in cole crops (broccoli, cauliflower, cabbage) and may be indicated by elongation of the leaf base. Apply Mo according to Table 7. Please note that over-application of micronutrients can result in plant damage.

Table 3. Recommended phosphorus application rates for vegetables[1]

Soil Series	Soil Test Category [2]	Very Low	Very Low	Medium	High	High
Cohoe, Island, Kenai, Naptowne, Soldotna, Tustumena	soil test (ppm)	4	35	66	97	128
	lb P2O5 to add/a	200	150	100	50	03
Beluga, Kachemak, Mutnala	soil test (ppm)	4	55	107	158	209
	lb P2O5 to add/a	200	150	100	50	03
Chulitna, Flathorn, Homestead, Nancy, Kashwitna, Schrock, Rabideaux, Whitsol, Talkeetna	soil test (ppm)	4	58	111	165	219
	lb P2O5 to add/a	200	150	100	50	03
Bodenberg, Doone, Knik, Matanuska, Niklason, Susitna	soil test (ppm)	43	70	96	123	150
	lb P2O5 to add/a	200	150	100	50	03
Beales, Chena, Fairbanks, Gilmore, Goldstream, Nenana, Steese	soil test (ppm)	6	61	115	170	225
	lb P2O5 to add/a	200	150	100	50	03
Jarvis, Richardson, Salchaket, Tanana, Volkmar	soil test (ppm)	6	39	72	106	139
	lb P2O5 to add/a	200	150	100	50	03

1 From Michaelson & Ping, 1989.

2 Mehlich 3 extraction.

3 When soil phosphorus tests are at the very high level and above, it is generally recommended that a small amount of phosphorus (about 50 lb P_2O_5/a) be applied as a starter fertilizer to provide adequate nutrition in cool soils.

Table 4. Salt-sensitivity of vegetable crops

Vegetable	Salt-Sensitivity
Beets	highly tolerant
Broccoli	moderately tolerant
Cabbage	moderately tolerant
Carrots	moderately tolerant
Cauliflower	moderately tolerant
Celery	sensitive
Cucumbers	moderately tolerant
Lettuce	moderately tolerant
Peas	moderately tolerant
Radishes	sensitive
Squash	moderately tolerant

Source: *Diagnosis and Improvement of Saline and Alkali Soils*. 1954. USDA Agriculture Handbook Number 60.

Tissue Analysis

Problems suspected to be caused by lack of nutrients often can be confirmed by plant tissue analysis. Plants of various ages differ in nutrient content; different plant parts also contain varying levels of plant nutrients. Therefore, it is critical that the plant structure collected is one for which standard values are known. In small plants, the whole above-ground portion of the plant is usually sampled. In older plants, the most common method of sampling is to collect the youngest fully mature (grown to its full size) leaf or to take the petioles (leaf stems) associated with those leaves. For those plants requiring leaf sampling, the petiole is usually not included. Petioles are often used for sampling soluble nutrients (nitrate, phosphate and potassium) because this is the conducting tissue where nutrients travel from the stem to the leaf and may provide a more sensitive test for these nutrients than leaf analysis. The recommended plant part for sampling various vegetable crops is given in Table 8.

If a field contains both healthy and unhealthy plants, leaf samples can be collected from both the healthy and unhealthy plants, making sure that the same plant part is taken in both cases. The healthy plant can then be used as the standard value to compare the unhealthy plant against.

Plant tissue samples should be taken from plants representative of the sampling area. Dead or damaged plants, those with insect or disease problems, those at the end of rows or in edge rows or plants that differ significantly from those in the rest of the planting should not be sampled. Plants that have been recently sprayed with foliar fertilizers should be avoided. It is important that at least the recommended number of plants are sampled to ensure that a representative sample is obtained. If the recommended sample size is 25 mature leaves, all leaves should be taken from separate plants. In addition, the sampled plants should be randomly selected from a field, not concentrated in one area.

Try to sample clean leaves. Leaves should be washed only if they are to analyzed for iron or aluminum. Washing should be done quickly in a mild (2%) detergent solution if required. Fresh tissue samples must be dried rapidly at 150 to 175 degrees F until all water is removed. Drying at higher temperatures may destroy plant tissues; drying at lower temperatures will not stop biological activity. Tissue samples will dry best in open containers, cloth bags, or opened paper bags. Samples should be dried immediately following sampling. If this is not possible, samples may be refrigerated for short periods of time prior to drying.

Nutritional status of the sampled plants can be evaluated by comparison with appropriate nutrient sufficiency ranges (Tables 9 and 10). It will often be impossible to correct nutritional problems in the same growing season the samples were collected. However, nutritional information from tissue analyses should be used to adjust fertility practices in subsequent years.

Table 5. Recommended potassium application rates for vegetables

Soil Test level (ppm)	Recommended Application Rate ($lb\ K_2O/a$)
0 – 75	180
76 – 150	120
151 – 300	60
Above 301	0

1 Mehlich 3 extraction.

Table 6. Recommended secondary nutrient application rates and sources for vegetables

Nutrient	Sources	Recommended Application Rates
Calcium	gypsum (CaSO4)	100 – 500 lb Ca/a if broadcast; 20 – 50 lb Ca/a if banded
Magnesium	epsom salts or kieserite (MgSO4), sulfate of magnesium potash or sulpomag (K2SO4 • 2MgSO4)	50 – 100 lb Mg/a if broadcast; 10 – 20 lb Mg/a if banded
Sulfur	elemental sulfur1, epsom salts, gypsum, sulpomag, ammonium sulfate (NH4)2SO4, potassium sulfate (K2SO4)	25 – 100 lb S/a

1 Elemental S should never be banded. As a broadcast treatment, 1,000 lb of elemental S/a generally will reduce soil pH between 1 to 2 units over time.

Table 7. Recommended micronutrient application rates and sources for vegetables

Nutrient	Sources	Recommended Application Rates
Boron	borax, solubor	1 lb B/a
Copper	copper chelates	1–2 lb Cu/a banded; or 4–8 lb Cu/a broadcast
Iron	iron sulfate ($FeSO_4$)	2.5–7.5 lb Fe as $FeSO_4$/a in 20 gallons water applied foliarly
Manganese	manganese chelates, manganese sulfate ($MnSO_4$)	3 lb Mn as $MnSO_4$/a or 0.5 lb Mn/a as Mn chelate banded; or 1 lb Mn in 20 gallons water applied foliarly
Molybdenum	sodium or ammonium molybdate	0.5 – 5 oz Mo/a broadcast; or 0.5 – 1.0 oz Mo/a in 20 gallons water applied foliarly
Zinc	zinc chelates or zinc sulfate ($ZnSO_4$)	1–2 lb Zn as chelate or 4–8 lb Zn/a as $ZnSO_4$ broadcast; or 0.15 lb Zn as chelate or 1 lb Zn/a as $ZnSO_4$ applied foliarly in 20 gallons water

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Table 8. Recommended plant part and stage of growth for selected vegetables

Crop	Number of Plants Sampled	Plant Part	Stage of Growth
Beets	20	YML1	at maturity
Broccoli	12	YML or midrib of YML	at heading
Brussels sprouts	12	YML or midrib of YML	at maturity
Cabbage	15	whole tops2	2–6 weeks old
Cabbage	12	wrapper leaf	2–3 months old
Carrot	15	YML or petiole of YML	mid-season
Carrot	15	oldest leaf	at maturity
Cauliflower	12	YML or midrib of YML	at heading
Celery	12	YML or petiole of YML	half-grown
Chinese cabbage	12	first fully developed leaf or midrib of YML	8-leaf stage
Chinese cabbage	12	rirst fully developed leaf or midrib of YML	at maturity
Romaine Lettuce	12	wrapper leaf	at maturity
Head Lettuce	12	wrapper leaf or midrib of wrapper leaf	heads half size
Turnip	12	YML	mid-growth

1 YML: youngest mature (fully expanded) leaf.

2 Whole tops are the entire above-ground portion of plants.

Table 9. Nutrient sufficiency ranges for selected vegetables[1]

Nutrient	Beets	Broccoli	Brussels sprouts	Cabbage 2-6 wks	Cabbage 2-3 months
			%		
Nitrogen	4.00 – 5.50	3.20 – 5.50	2.20 – 5.50	3.00 – 5.00	3.00 – 5.00
Phosphorus	0.25 – 0.50	0.30 – 0.75	0.26 – 0.75	0.35 – 0.75	0.30 – 0.75
Potassium	2.00 – 4.50	2.00 – 4.00	2.00 – 4.00	3.50 – 6.00	3.00 – 5.00
Calcium	2.50 – 3.50	1.00 – 2.50	0.30 – 2.50	3.00 – 4.50	1.10 – 3.50
Magnesium	0.30 – 1.00	0.23 – 0.75	0.23 – 0.75	0.50 – 2.00	0.24 – 0.75
Sulfur	——	0.30 – 0.75	0.30 – 0.75	——	0.30 – 0.75
			ppm		
Boron	30 – 85	30 – 100	30 – 100	25- –	25 – 75
Copper	5 – 15	5 – 15	5 – 15	5 – 15	5 – 15
Iron	50 – 200	70 – 300	60 – 300	30 – 200	30 – 200
Manganese	50 – 250	25 – 200	25 – 200	50 – 200	25 – 200
Molybdenum	——	——	0.25 – 1.00	——	0.40 – 0.70
Zinc	15 – 200	35 – 200	25- – .00	25 – 200	20 – 200

Nutrient	Carrots mid-season	Carrots mature	Cauliflower	Celery	Chinese Cabbage
			%		
Nitrogen	1.80 – 3.50	3.00 – 3.50	3.00 – 4.50	2.50 – 3.50	4.50 – 5.50
Phosphorus	0.20 – 0.50	0.20 – 0.40	0.33 – 0.80	0.30 – 0.50	0.50 – 0.60
Potassium	2.00 – 4.30	2.90 – 3.50	2.60 – 4.20	4.00 – 7.00	7.50 – 9.00
Calcium	1.40 – 3.00	1.00 – 2.00	0.70 – 3.50	0.60 – 3.00	3.00 – 5.50
Magnesium	0.30 – 0.53	0.25 – 0.60	0.24 – 0.50	0.20 – 0.50	0.35 – 0.50
			ppm		
Boron	29 – 100	30 – 75	30 – 100	30 – 50	23 – 75
Copper	4.5 – 15	5 – 15	4 – 15	5 – 8	5 – 25
Iron	50 – 300	50 – 300	30 – 200	20 – 40	31 – 200
Manganese	60 – 200	60 – 200	25 – 250	200 – 300	25 – 200
Molybdenum	0.5 – 1.5	0.5 – 1.4	0.5 – 0.8	——	——
Zinc	20 – 250	20 – 250	20 – 250	20 – 50	30 – 200

Nutrient	Romaine Lettuce	Head Lettuce	Turnip
		%	
Nitrogen	3.50 – 4.50	3.50 – 5.00	3.50 – 5.00
Phosphorus	0.45 – 0.80	0.40 – 0.60	0.33 – 0.60
Potassium	5.50 – 6.20	6.00 – 9.60	3.50 – 5.00
Calcium	2.00 – 2.80	1.40 – 2.25	1.50 – 4.00
Magnesium	0.60 – 0.80	0.36 – 0.70	0.30 – 1.00
		ppm	
Boron	25 – 60	23 – 50	30 – 100
Copper	5 – 25	7 – 25	6 – 25
Iron	40 – 100	50 – 175	40 – 300
Manganese	11 – 250	20 – 250	40 – 250
Zinc	20 – 250	25 – 250	20 – 250

[1] Standard nutrient levels are for plant parts and growth stages specified in Table 8.

Table 10. Sufficiency levels for nitrate, phosphate and potassium in petioles and leaf midribs of vegetables

Crop	Stage of Growth	Plant Part	Nitrate-N (ppm)	Phosphate-P (ppm)	Potassium (%)
Broccoli	mid-growth	midrib of YML[1]	>9,000	>4,000	>5.0
	first buds		>7,000	>4,000	>4.0
Brussels sprouts	mid-growth	midrib of YML	>9,000	>3,500	>5.0
	late growth		>7,000	>3,000	>4.0
Carrot	mid-growth	petiole of YML	>10,000	>4,000	>6.0
Cauliflower	head-forming	midrib of YML	>9,000	>5,000	>4.0
Celery	mid-growth	petiole of YML	>9,000	>5,000	>6.0
	near mature		>6,000	>3,000	>5.0
Chinese cabbage	heading	midrib of wrapper leaf	>9,000	>3,500	>4.0
Head lettuce	heading	midrib of	>8,000	>4,000	>4.0
	harvest	wrapper leaf	>6,000	>2,500	>2.5

[1] YML: youngest mature (fully expanded) leaf.

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