SUPPLEMENTAL TECHNICAL REPORT FOR SODIUM NITRATE (CROPS)

The National List of Allowed and Prohibited Substances (hereafter referred to as the National List) identifies sodium nitrate ($NaNO_3$) as a prohibited nonsynthetic substance that may be used in organic crop production under limited conditions. In particular, sodium nitrate is prohibited from organic crop production unless use is restricted to no more than 20% of the crop's total nitrogen requirement (7 CFR 205.602). This listing is scheduled to expire on October 21, 2012, and is currently under review by the National Organic Standards Board (NOSB). Previous Technical Reports relevant to sodium nitrate use in organic crop production include the following:

- Technical Advisory Panel (TAP) Review of Chilean Nitrate for General Use (2002a)
- TAP Review for Chilean Nitrate for use in Spirulina aquaculture production (2002b)
- TAP Review for Sodium Nitrate (1995)

This Supplemental Technical Report responds to six questions posed by the NOSB Crops Committee to aid the sunset review.

A. How is sodium nitrate mined, processed, and handled before sale?

Beginning in the mid-1800s, the first commercially utilized nonsynthetic source of nitrate fertilizer, guano, was obtained from island deposits where seabird excrement had accumulated over thousands of years. These deposits were quickly depleted, and commercial fertilizer production shifted to the mining of sodium nitrate mineral deposits, primarily from Chile and Peru. Mined sources in Chile remain the primary source (greater than 90%) of the world's mined sodium nitrate, and the United States (US) is a leading consumer (Vis, 2010). However, nonsynthetic sodium nitrate accounts for a very small amount of the nitrogen fertilizer used in US agriculture. In 2001, 75,000 tons of Chilean nitrate were sold to farmers in the US and constituted 0.14% of the total US fertilizer application (Urbansky et al., 2001).

South American nitrate fertilizer in its raw form is a layer of mineral several centimeters thick referred to as 'caliche.' Calcihe deposits are crude mineral conglomerates of salts, possibly formed from nitrogen fixation by microorganisms in playa lakes and associated soils approximately 10 to 15 million years ago (USDA, 2002a). In addition to sodium nitrate, caliche is comprised of sulfates, chlorides of sodium, calcium, potassium, magnesium, and various micronutrients including borate, iodate, and perchlorate (USDA, 2002a).

Because caliche is located close to the surface, it is recovered by open-pit mining (SME, 2006). In an open pit mine, the first layer of caliche is stripped using heavy equipment and is accumulated at the sides of the mining pit. Blasting and drilling are used to loosen the material for removal. The material is then hauled, crushed, and placed to a leaching pad where extraction methods (described further below) are performed. Leach pads usually consists of a geomembrane liner and a permeable crushed rock drainage system with a drainage pipe network (Atacama Minerals Ltd., 2010). Processed ore, or tailings, are pumped to a settling pond where the process water evaporates.

Mineral extraction from caliche is performed with the Guggenheim process (SME, 2006). In the Guggenheim process, crushed caliche ore is transferred to large vats where countercurrent leaching takes place with the addition of a heated leaching solution. This solution is comprised of weak brines created in the washing steps of the leaching cycle, freshwater, and mother liquor from the nitrate crystallization plant. Fresh water is important as it allows the sodium nitrate to selectively dissolve out of the total solution. The crystallized sodium nitrate is separated with a centrifuge. Use of a closed-circuit system allows the mother liquor to be recycled and it is transferred to a leaching vat for future use (SME, 2006).

When shipped, sodium nitrate is considered hazardous as it is a strong oxidizer (i.e., highly reactive). Generally, sodium nitrate is shipped on pallets containing large, fifty pound bags (Fertilizer Brokerage, 2010). Sodium nitrate should be stored in cool, dry locations away from inflammable organics or easily oxidizable substances. It should not be stored on wooden floors and should be handled only with rubber gloves and safety glasses (HSDB, 2007).

B. What are effects of those activities on the environment?

Open pit mining, in general, has a number or potential impacts on the environment, including impacts on air and water quality, aesthetics, noise and vibrations (e.g., from blasting) and hydrological changes. Mining impacts are associated with the surface mine and related infrastructure, including the mineral processing plant, access or haul roads, remote facilities, and waste (tailings) management units and impoundments (Kubach, 2010). In caliche ore mining, specifically, waste products, including sand and rock tailings, are often dumped on land and into water sources. Waste materials from open pit caliche mines contain nitrates and contaminate soils and eventually may reach the water table and contaminate water supplies (Muniz, 1996).

During ore and tailings handling and processing, it is possible that sodium nitrate may be released to air, water, and soil. Sodium nitrate dust is considered irritating to the respiratory tract if inhaled and may cause shortness of breath and coughing in exposed workers in mining or processing facilities (J.T. Baker, 1996). If released to the soil, sodium nitrate is likely to leach down the soil profile as it is very soluble. Specifically, nitrate is highly mobile and is likely to enter the water table if not first taken up by plants and other soil dwelling organisms, a common occurrence if released in areas that are already high in nitrogen. Increases in soluble soil nitrates caused decreases in earthworm (USDA, 2002a). If a high level of nitrogen is already present in the soil then plants and soil organisms may not be able to assimilate any of the nitrogen in the soil causing the remaining nitrogen to leach, resulting in water pollution and contamination of water supplies (Barbarick, 2006).

Sodium nitrate is a common non-point source water contaminant, particularly in agricultural areas, and is regulated under the Clean Water Act. Sodium nitrate is quickly ionized into sodium (Na^+) and nitrate (NO_3^-) in water. In water, a high nitrate concentration, and even a low chronic level in aquatic systems, can be toxic to aquatic organisms (USDA, 2002a). Nitrate contamination of freshwater streams and rivers is also a concern. One study by Scott and Crunkilton (2000) found ambient levels of surface water nitrate in areas of intensive agricultural cultivation to be toxic to channel catfish, *Ceriodaphnia dubia* (USDA, 2002a).

If released to water and soil, the impacts of nitrates on human health are potentially significant. Following ingestion, the body reduces nitrate to nitrite, which has been linked to methemoglobinemia, a potentially fatal condition whereby nitrites interfere with oxygen uptake. Nitrites can be further reduced to nitrosamines, a class of compounds considered to be known carcinogens. Nitrosamines have been found to induce cancer in a variety of organs in more than forty animal species, including higher primates. In rural Iowa, a study of contaminated municipal drinking water linked nitrates to a higher risk of bladder cancer in older women. An increase in the incidence of non-Hodgkin's lymphoma has also been linked to elevated nitrate concentrations (USDA, 2002a).

The transport of sodium nitrate from mines to shipping ports and the use of heavy machinery in mining efforts may contribute to the level of air pollution and the release of greenhouse gases (Muniz, 1996). In addition, to support mining in isolated areas, railroad track is often laid across the landscape, potentially causing soil erosion (Vis, 2010).

C. What are typical use patterns of sodium nitrate in organic crop production? Given those use patterns, how much sodium can be expected to be contributed to the farm ecosystem with compliant applications of sodium nitrate?

Sodium nitrate fertilizer can be dissolved and applied as an aqueous solution, broadcast, drilled, or used as a sidedress (USDA, 2002a). Sodium nitrate is a particularly effective fertilizer because all of the nitrogen present in the substance is readily available for crop uptake. In addition, the nitrogen in sodium nitrate has a neutralizing effect on soil and subsoil acidity; does not interfere with absorption of potassium, magnesium and calcium by plants; does not volatilize to the atmosphere in the form of ammonia; and acts more quickly than the nitrogen in synthetic nitrogen fertilizers. Nitrates are easily available to crops when applied to soils during times of low rainfall and cold weather and acidic soil conditions. Specifically, sodium nitrate fertilizer is an effective nitrogen source for tobacco, vegetable crops, sugar beets, and cotton, and for any crops grown in acidic soils (Kirk-Othmer Encyclopedia of Chemical Technology, 2006).

Sodium nitrate is a salt that dissociates into sodium ($Na+$) and nitrate (NO_3-) ions in water. When sodium nitrate fertilizers dissolve in soil, they increase the sodium concentration of the soil as well as the nitrate utilized by growing plants. Sodium is relatively immobile in soils and is likely to accumulate in soils in semi-arid and arid environments (A & L Great Lakes Laboratories, 2002). Salinity stress is a major cause of loss in agricultural productivity, and salinization is a limiting factor in the beneficial application of sodium nitrate to crops (USDA, 2002a).

Sodium is locally persistent while nitrate is not. The molecular orientation of clay surfaces and organic matter produce a net negative charge in soil. Thus, it binds positively charged cations, like $Na+$, much more strongly than it does negatively charged anions, such as NO_3^-. Therefore, sodium will not leach from the soil profile and is not taken up by plants in amounts significant enough to reduce the overall load. An excess of sodium in the soil will raise its overall pH and breakdown the soil aggregate, which negatively affects the overall soil structure. This results in severe drainage problems that increase sodium accumulation (USDA, 2002a).

The use of sodium nitrate is prohibited by the International Federation of Organic Agriculture Movements (IFOAM) and most other standards for organic production, including those in Canada. In the US, sodium nitrate is prohibited from organic crop production unless use is restricted to no more than 20% of the crop's total nitrogen requirement (7 CFR 205.602). Therefore, calculation of the amount of sodium nitrate permitted is critical, and growers must first determine the amount of nitrogen recommended for the crop. Nitrogen requirements and recommendations vary by crop and this information is usually contained within a soil test report in local production guides. To determine how much of the recommended nitrogen can be supplied by using sodium nitrate, growers can multiply the recommended rate by 0.20 (i.e., 20%) (Sanchez and Richard, 2006).

Table 1, which is based on information from Dramm Corp (2005), a distributor of Chilean nitrate, provides estimates of the nitrogen requirements for major crops grown on organic farms in the Midwestern United States. Chilean nitrate contains roughly 27% sodium in addition to the nitrogen (16%) and some trace elements. The projected amount of sodium was calculated by assuming that 27% of the sodium nitrate product is considered as sodium (Kirk-Othmer Encyclopedia of Chemical Technology, 2006).

Table 1: Per Acre Applications of Nitrogen Required for Select Crops Grown on Organic Farms in the Midwestern United States

Crop	Amount of N Required (lbs./acre)	Maximum NOP Allowed 20% of Requirement (lbs./acre)	Projected Amount of Chilean Nitrate 16-0-0[1] (lbs./acre)	Projected Amount of Sodium in Application of Maximum NOP Allowance (lbs./acre)
Field Crops				
Winter wheat	80-100	16-20	100-130	27-35.1
Spring wheat	80-100	16-20	100-130	27-351
Oats, barley, spelt	60-80	12-16	75-100	20.25-27
Corn	120-150	24-30	150-180	40.5-48.6
Sweet corn	80-100	16-20	100-130	27-35.1
Pasture-grass	100-120	20-24	120-150	32.4-40.5
Soybean	8-15	1.5-3	10-20	2.7-5.4
Alfalfa-low OM soil	8-10	1.5-2	10-12	2.7-3.24
Cotton	50-75	10-15	60-100	16.2-27
Peanuts	80-120	16-20	100-130	27-35.1
Vegetables				
Potatoes	180-200	36-40	225-250	60.75-67.5
Cole Crops	150-175	24-35	150-200	40.5-54
Green Beans	60-80	12-16	75-100	20.25-27
Cucurbit	100-150	20-30	120-180	32.4-48.6
Onions, Leeks, Garlic	100-150	20-30	120-180	32.4-48.6
Tomatoes	100-150	20-30	120-180	32.4-48.6
Carrots	100-150	16-20	120-180	32.4-48.6

Source: Dramm Corp. (2005)

[1] 16-0-0 refers to the percentage of nitrogen, phosphate, and potash contained in a fertilizer product. Typical Chilean nitrate is 16-0-0 (i.e., contains 16% nitrogen and negligible phosphate and potash).

D. How does this amount of sodium compare with uses of other fertilizers and soil amendments used in organic crop production?

To compare the salinization potential of available fertilizers, agronomists use the Salt Index (SI), which is a relative measure of the salt concentration that fertilizers induce in soil solutions. The Salt Index uses sodium nitrate as the benchmark substance with and SI rating of 100 (A & L Great Lakes Laboratories, 2002; USDA, 2002a). Table 2 provides the Salt Index values for some commonly used nitrogen fertilizers.

Animal manures, both raw and composted, are permitted by the USDA for use in organic crop production. Specifically, animal manure may be used according to the following regulatory restrictions:

Raw animal manure must be composted unless it is:

- Applied to land used for a crop not intended for human consumption;
- Incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or
- Incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles (7 CFR 205.203(c)(1)).

Table 2: Salt Index of Fertilizer Materials and Soil Amendments

Material and Analysis	Salt Index
Nitrogen Fertilizers	
Sodium nitrate, 16.5% N	100.0
Calcium nitrate, 15.5% N	65.0
Anhydrous ammonia, 82% N	47.1
Ammonium nitrate, 34% N	104.0
Ammonium sulfate, 21% N, 24% S	88.3
Urea, 46% N	74.4
Miscellaneous	
Calcium carbonate, lime, 35% Ca	4.7
Dolomite, 21.5% Ca, 11.5% Mg	0.8
Manure salts, 20%	112.7
Manure salts, 30%	91.9

Source: A & L Great Lakes Laboratories, 2002

Composted animal materials must be produced though a process that:

- Established an initial C:N ratio of between 25:1 and 40:1; and
- Maintained a temperature of between 131 °F and 170 °F for 3 days using an in-vessel or static aerated pile system; or
- Maintained a temperature of between 131 °F and 170 °F for 15 days using a windrow composting system, during which period, the materials must be turned a minimum of five times (7 CFR 205.203(c)(2)).

The composting of animal manure can decrease the overall nitrogen content (e.g., through volatilization) of the material (Mikkelsen and Hartz, 2008). Therefore, a larger amount of composted animal manure than raw manure would be needed to provide an adequate amount of nitrogen, and the sodium addition from composted manure may be greater than sodium addition from raw manure.

The concentration ratio of sodium to nitrogen in manure can be used to estimate the amount of sodium that would be added to the soil following application. The actual concentration of raw (uncomposted) manure components including sodium, nitrogen, and water can greatly vary in different samples (The Ohio State University, 2010; Mikkelsen and Hartz, 2008). Table 3 provides a comparison of the sodium addition to the soil in raw manures.

Table 3: Sodium Addition to the Soil Following Application of Raw Manure[1]

Manure Type	Amount of Nitrogen in Manure (%)	Amount of Manure (lbs.) Required to Add 80 lbs. of N per Acre	Weight Ratio of Sodium to Total Nitrogen in Manure	Sodium Addition to the Soil in lbs.	Data Sources
Poultry	3.5	2,285	0.17	13.6	Zublena et al., 1993; USDA, 2002a
Dairy	1	8,000	0.21	16.8	Meyer et al. 1976; Jones and Sanderson, 1997

[1] The estimates presented are for a crop that is assumed to require 80 pounds of nitrogen per acre.

It is important to consider that the weight ratio of sodium to total nitrogen in composted manure might be significantly higher than the values given in Table 3. Therefore it is possible that the application of composted manure may add even more sodium to a soil than the application of sodium nitrate because more processed manure will need to be added in order to provide the same total amount of nitrogen to the soil.

The following example provides a hypothetical comparison of sodium additions from Chilean nitrate fertilizer and raw manure. Using information presented in Table 1, a winter wheat crop may require from 80 to 100 pounds of nitrogen per acre. Because only 20% of the nitrogen requirement may come from Chilean nitrate, the allowable amount of nitrogen per acre from Chilean nitrate would be 16 to 20 pounds per acre. Assuming that Chilean nitrate fertilizer is 16 percent nitrogen, the amount of Chilean nitrate fertilizer added per acre would be 100 to 125 pounds per acre. The estimated sodium content of Chilean nitrate fertilizer is 27% (Kirk-Othmer Encyclopedia of Chemical Technology, 2006). Therefore, the amount of sodium added to the soil would be 27 to 33.8 pounds per acre. Using poultry manure to supply the same 16 to 20 pounds per acre of nitrogen, it would be necessary to apply from 457 to 571 pounds of manure per acre. (Note that much more manure, 2,286 to 2,857 pounds per acre, would be needed to supply the full 80 to 100 pound per acre nitrogen requirement of the crop.) Assuming that the weight ratio of sodium to total nitrogen in poultry manure is 0.17, the amount of sodium added from the manure would be 2.7 to 3.4 pounds per acre. This comparison indicates that to add the same amount of nitrogen, the manure adds about on tenth of the sodium added by Chilean nitrate fertilizer. These calculations use information for untreated manure. The amount of manure, and thus sodium, added would be larger if treated manure were used

The Organic Food Production Act (OFPA) allows the use of bone, blood, and feather meal as nonsynthetic fertilizer products suitable for use in organic agriculture (7 CFR 205.105). These materials must have been treated or handled in a way that reduces contamination by specified risk materials and food-borne pathogens and meets standards for indicator pathogens (OMRI, 2010a). No information has been identified on the sodium content of these materials or the impacts of their use on soil sodium levels

E. What if any negative impact does this sodium contribution have on organic soil ecosystems, nutrient availability, physical soil properties and tilth?

Chilean sodium nitrate fertilizer contains approximately 27% sodium (Kirk-Othmer Encyclopedia of Chemical Technology, 2006). The use of sodium nitrate can benefit soils with low pH and sodium levels, but can easily harm a high sodium and high pH soil. Nutrient availability is low in soils with a high pH and a further increase in soils with an already high pH will only exacerbate the problem. It is likely that different soil types will react differently to the addition of sodium nitrate and characterizing the direct impact of sodium nitrate on soils is difficult. The use of sodium nitrate may not be compatible with certain soil types and its use should be evaluated before application (Magdoff, 2009).

When sodium nitrate is applied to a heavy soil it can produce sodium clay with a distinct lack of tilth and structure. Too much sodium in the soil makes the soil sodic. Sodic soils are those that have a badly dispersive, hard-setting and easily-compacted structure. Well-structured soils have high levels of exchangeable calcium, whereas sodic soils have high levels of sodium where there should be calcium. Calcium is important because it creates good soil stability, holds soil particles together, promotes water aeration and infiltration, and allows for root penetration. Because sodium ions possess only half the charge as calcium, they do not hold soil particles together well, creating soils with poor water infiltration, aeration, root penetration, and soil compaction (USDA, 2002a). A change in the soil aggregate can cause drainage issues that only heighten the impact of sodium accumulation. The effects are greater in areas where poor rainfall, high evaporation, and badly drained soils inhibit leaching and further the accumulation of salt from incoming water. The highest risk is observed in irrigated systems and semi-arid environments. Salt related soil deficiencies are more difficult to remedy than nutrient deficiencies (USDA, 2002a).

It may be difficult to determine if the sodium introduced to the soil when applying sodium nitrate in the regulated amount will produce sodic soils. It is important that soil conditions be monitored and analyzed prior to the application of sodium nitrate fertilizers (USDA, 2002a).

High salinity levels in soil will hinder the growth of crops and can prevent seeds from germinating in the soil as well as damage plants that are already growing (USDA, 2002a). An increase in salt concentration increases the osmotic potential of the soil solution. The higher the osmotic potential of a solution, the more difficult it is for seeds or plants to extract soil water they need for normal growth (A & L Great Lakes Laboratories, 2002). Leaves may turn black, blue, or yellow, drop off, or appear burned. Observations of stunted growth of plants or leaves that appear smaller than normal in size are additional indications that salinity levels in the soil are too high (USDA, 2002a).

Soil pH and organic matter content can significantly affect soil microbial biomass. If sodium nitrate is applied as directed and to the appropriate types of soils, it is generally not likely that sodium nitrate will negatively affect the soil pH. Soil fauna and flora similarly are not expected to be negatively affected. This can be explained by the fact that the nitrate and sodium soil concentration will remain well within their natural range when sodium nitrate is used as intended. However, excessive application of sodium nitrate can cause adverse effects on soil fauna and flora by altering the soil pH due to the increase in sodium (Kirk-Othmer Encyclopedia of Chemical Technology, 2006).

F. What alternative practices and materials are available to supply nitrogen to organic crops?

Alternative Materials

Many products are available as alternatives to sodium nitrate for adding nitrogen to the soil. However, most of these products do not supply nitrogen to the soil as quickly as sodium nitrate. These products provide a slow release of nitrogen and will not offer a 'quick fix' when nitrogen must be supplied immediately.

As discussed in Question D., raw or composted animal manure may be used to supply nitrogen to the soil. The US regulations for organic production require that raw animal manure must be composted unless it is applied to land used for a crop not intended for human consumption; or is incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with soil; or is incorporated into the soil not less than ninety days prior to the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles (7 CFR 205.203 (c)(1) and (2)).

Poultry manure is higher in nitrogen (3.5%) than dairy manure (1%) and is favored as a fertilizer (Grubinger, 2010). Composting reduces the amount of nitrogen present in the manure, but applications of raw, unprocessed manure can be used on food crops provided it is applied a suitable number of days prior to harvest. Raw manure can also be applied on cover crops that are not for human consumption, which is a strategy used by some organic farmers to store nitrogen in the soil organic matter complex (Magdoff, 2009). The Organic Materials Review Institute (OMRI) lists many heat processed manure products (OMRI, 2011e).

Composted or uncomposted or plant material are permitted for use in organic crop production (7 CFR 205.203(c)(2) and 7 CFR 205.203(c)(3)). Decomposing plant materials provide a slowly releasing supply of nitrogen. These materials are not as effective as sodium nitrate in situations where large amounts of nitrogen are needed quickly. It is estimated that 24 pounds of nitrogen is present in every one ton of composting material (e.g., materials that are high in nitrogen including manure, coffee grounds, grass clippings, and kitchen waste; and materials that are high in carbon including leaves, newsprint, and woodchips) (Grubinger, 2010). For comparison, one ton of sodium nitrate fertilizer contains an estimated 320 pounds of nitrogen.

Several types of meals (e.g., bone meal) are considered high in nitrogen and could be used as a plant or soil amendment. Blood, bone, and feather meals are considered nonsynthetic and are allowed for use in organic crop production (7 CFR 205.105).

Bone meal is a slaughterhouse byproduct created from the sterilized bones of animals. Bone meal is generally used to add phosphorous to the soil, but also can act as a source of nitrogen. Because bone meal slowly releases nutrients to the soil, the material is sometimes supplemented with substances such as potassium chloride in order to speed up the release. Before applying bone meal it is important to verify that the pH of the soil is not too high as the calcium in the product can further increase the soil pH. Bone meal has been reported to reduce the formation of beneficial micorrhyzal fungi (1). Bone meal is estimated to contain 80 pounds of nitrogen per ton (Grubinger, 2010). Products vary in their respective percentages of nitrogen, phosphorous, and potassium. Below is a listing of currently manufactured products (OMRI, 2011b) containing bone meal:

- Down to Earth Bone Meal 3-15-0: Down to Earth Distributors Inc., P.O. Box 1419, Eugene, OR, 97440
- Down to Earth Fish Bone Meal 3-16-0: Down to Earth Distributors Inc., P.O. Box 1419, Eugene, OR, 97440
- Granulated Steamed Bone Meal: Pacific Calcium Inc., 32117 Highway 97, Tonasket, WA 98855
- GroundsKeeper's® Pride Granulated Bone Meal 2-14-0: International Compost, Ltd., 233187 Range Road 283, Rocky View, AB T1X0J9, Canada
- Miracle-Gro® Organic Choice® Bone Meal: Scott's Miracle-Gro Products Inc., 14111 Scottslawn Rd., Marysville, OH 43041
- Par4® 2-14-0 Granulated Steamed Bone Meal: Bridgewell Resources, LLC., 12420 SE Carpenter Drive, Clackamas, OR 97015
- Phyta-Grow® Bone Meal 4-14-0: California Organic Fertilizers, 7600 N Ingram Ave., Suite 121, Fresno, CA 93711
- Wegener's Brand Granulated Bone Meal 2-14-0: Rambridge Wholesale Supply, #1-2421 Centre Ave. SE, Calgary, AB T2E 0A9, Canada

Blood meal also is a by-product of animal processing (i.e., slaughterhouses). The blood protein present in the meal is broken down by soil bacteria to form ammonia. It is estimated that 260 pounds of nitrogen is present in one ton of blood meal (Grubinger, 2010). Products vary in their respective percentages of nitrogen, phosphorous, and potassium. Currently manufactured products (OMRI, 2011a) containing blood meal are listed below:

- Boost Natural 11-0-5: The F.A. Bartlett Tree Expert Company, 13768 Hamilton Rd., Charlotte, NC 28276
- Down to Earth Blood Meal 12-0-0: Down to Earth Distributors Inc., P.O. Box 1419, Eugene, OR 97440
- GroundsKeeper's® Pride Blood Meal 12-0-0: International Compost, Ltd., 233187 Range Road 283, Rocky View, AB T1X0J9, Canada
- Miracle-Gro® Organic Choice® Blood Meal: Scott's Miracle-Gro Products Inc., 14111 Scottslawn Rd., Marysville, OH 43041
- Phyta-Grow® Big Red 13-0-0: California Organic Fertilizers, 7600 N Ingram Ave., Suite 121, Fresno, CA 93711

- Wegener's Brand Blood Meal 12-0-0: Rambridge Wholesale Supply, #1-2421 Centre Ave. SE, Calgary, AB T2E 0A9, Canada

Feather meal contains approximately 13% nitrogen (i.e., 260 pounds per ton), however products vary in their respective percentages of nitrogen, phosphorous, and potassium. The nitrogen content of feather meal is derived from keratin, a protein that occurs in hair, hoofs, horns, and feathers. The tight structure of keratin makes the substance not easily broken down by soil bacteria. This attribute makes feathers an excellent long-term source of nitrogen but is not appropriate for the plant's immediate nitrogen needs (North Country Organics, 2011). Below is a listing of currently available feather meal products (OMRI, 2011c):

- Down to Earth Feather Meal 12-0-0: Down to Earth Distributors Inc., P.O. Box 1419, Eugene, OR, 97440
- Foster Farms Feathermeal: 12997 W Hwy. 140, Livingston, CA 95334
- Granulated Feather Meal: Pacific Calcium Inc., 32117 Highway 97, Tonasket, WA 98855
- Griffin Feather Meal 12-0-0: Griffin Industries, Inc., 4221 Alexandria Pike, Cold Spring, KY 41076
- Par 4 Granulated Feather Meal 13-0-0: Bridgewell Resources, LLC., 12420 SE Carpenter Drive, Clackamas, OR 97015
- Phyta-Grow® Super "N"™ 12-0-0: California Organic Fertilizers, 7600 N Ingram Ave., Suite 121, Fresno, CA 93711
- True 12-0-0: True Organics Products Inc., P.O. Box 7192, Spreckles, CA 93962

The National List identifies liquid fish as a synthetic product allowed for use in organic crop production as a plant or soil amendment (7 CFR 205.601). Liquid fish fertilizers are created when fish and fish scraps are ground and then cold processed using enzymes that cause the product to liquefy. Liquid fish products can be pH adjusted with sulfuric, citric, or phosphoric acid, but the amount of acid used should not exceed the minimum needed to lower the pH to 3.5 (7 CFR 205.601). These products contain a level of nitrogen similar to that found in chicken manure (i.e., 3.5%). The Organic Materials Review Institute's (OMRI) Products List identifies more than 25 liquid fish fertilizer products (OMRI, 2011d).

Rhizobium bacteria are nonsynthetic and are permitted for use in organic agriculture (7 CFR 205.203). Rhizobia are nitrogen fixing soil bacteria that are housed inside of the root nodules of plants. Legumes and rhizobia are mutually dependent and the presence of the bacteria makes the legume independent of soil nitrogen (Kimball, 2011).

Alternative Practices

Certain cover crops can augment soil nitrogen if grown in a crop rotation system that includes the appropriate amount of land. The use of cover crops, which are sometimes referred to as "green manures," helps avoid depletion of valuable soil nutrients, including nitrogen, by augmenting nitrogen levels or balancing the demands of different types of plants (USDA, 1996).

Legumes are particularly useful in cover crop rotation systems because they establish symbiotic relationships with bacteria (called *Rhizobia*) capable of nitrogen fixation, the process where atmospheric nitrogen is converted into a biologically useable form. Nitrogen fixation provides legumes with a significant advantage because they are able to grow in nitrogen poor soils. Legume crops may contain 100 to 200 pounds of nitrogen per acre, and when the plants die the fixed nitrogen is released and becomes available to other plants (e.g., non-nitrogen-fixing field crops in a rotation system) (Sanchez and Richard, 2006).

Common nitrogen-fixing legumes include alfalfa, clover, field peas, and hairy vetch. Incorporating the appropriate amounts of legume crop early in the season can provide most if not all the nitrogen needed by a subsequent vegetable crop. For successful use of legumes nitrogen fixation, it is important that adequate time be allowed for the cover crop to produce enough biomass. The approximate nitrogen credit from the use of nitrogen fixing legumes varies among crops. Alfalfa can add between 50 and 100 pounds of nitrogen per acre, clover add between 50 and 130, field peas add between 172 and 190, and hairy vetch can add 50 to 100 pounds of nitrogen per acre for future crop use, respectively (Sanchez and Richard, 2006; Magdoff, 2009).

References:

A & L Great Lakes Laboratories, Inc., 2002. Fertilizer Salt Index, Retrieved February 25, 2011 from http://www.algreatlakes.com/PDF/factsheets/ALGLFS15_Fertilizer_Salt_Index.PDF

Atacama Minerals Ltd., 2010. Retrieved January 26, 2011 from http://www.atacama.com/s/AguasBlancas.asp?ReportID=109034

Babarick, K.A., 2006. Nitrogen Sources and Transformations, Retrieved January 26, 2011 from http://www.ext.colostate.edu/pubs/crops/00550.html

Dramm Corp., 2005. Chilean Nitrate, Retrieved January 26, 2011 fromhttp://www.dramm.com/media/fish/grower/2006%20Chilean%20Nitrate%20application%20rates.pdf

Fertilizer Brokerage, 2010. Chilean Nitrate 13-0-0, Retrieved February 9, 2011 from http://www.fertilizerbrokerage.com/index.php?option=com_content&view=article&id=44&Itemid=54

Grubinger, V., 2010. Sources of Nitrogen for Organic Farms, Retrieved February 8, 2011 from http://www.uvm.edu/vtvegandberry/factsheets/organicN.html

HSDB, 2007. Sodium Nitrate, Retrieved February 24, 2011 from http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~KAI01t:1

J.T. Baker, 1996. MSDS: Sodium Nitrate, Retrieved March 3, 2011 from http://www.ethanolresearch.com/engineering/civilengineering/pdf/msds/119.pdf

Kimball, J., 2011. Symbiotic Nitrogen Fixation, Retrieved February 24, 2011 from http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/N/NitrogenFixation.html

Kirk-Othmer Encyclopedia of Chemical Technology, 2006. Sodium Nitrate and Nitrite, Vol. 22, 5th edition, Retrieved February 24, 2011 from http://www.scribd.com/doc/30122669/Sodium-Nitrate-and-Nitrite.

Kubach, C., 2010. Open Pit Surface Mine, Retrieved January 21, 2011 from http://www.mine-engineer.com/mining/open_pit.htm

Magdoff, F., 2009. Building Soils for Better Crops: Sustainable Soil Management, Retrieved March 18, 2011 from http://www.sare.org/publications/bsbc/bsbc.pdf

Meyer, J., Rauschkolb, R., and Olson, E., 1976. Dairy Manure can be Used Safely, California Agriculture, pg. 10-11.

Mikkelsen, R. and Hartz, T.K., 2008. Nitrogen sources for organic crop production. Better Crops, 92, 16-19.

Muniz, A., 1996. Chile Nitrates Export, American University Trade and Environmental Database, Retrieved January 21, 2011 from http://www1.american.edu/TED/nitrate.htm

North Country Organics, 2010. Natural Fertilizers, Retrieved February 8, 2011 from http://www.norganics.com/products/fertilizers/feather-meal.html

OMRI, 2011a. Blood meal, Retrieved February 8, 2011 from http://www.omri.org/simple-opl-search/results/blood%20meal

OMRI, 2011b. Bone meal, Retrieved February 8, 2011 from http://www.omri.org/simple-opl-search/results/bone%20meal

OMRI, 2011c. Feather meal, Retrieved February 8, 2011 from http://www.omri.org/simple-opl-search/results/feather%20meal

OMRI, 2011d. Fish Products, Liquid – stabilized, Retrieved February 24, 2011 from http://www.omri.org/simpleoplsearch/results/Fish%20Products%2C%20Liquid%20%E2%80%93%20stabilized

OMRI, 2011e. Manure-processed, Retrieved February 8, 2011 from http://www.omri.org/simple-opl-search/results/manure%2C%20processed

OMRI, 2011f. Guano, Retrieved February 8, 2011 from http://www.omri.org/simple-opl-search/results/guano

The Ohio State University Extension, 2010. Best Management Practices: Land Application of Animal Manure, Retrieved February 9, 2011 from http://ohioline.osu.edu/agf-fact/0208.html

Sanchez, E.S. and Richard, T.L., 2006. Using Organic Nutrient Sources, The Pennsylvania State University, Retrieved February 25, 2011 from http://pubs.cas.psu.edu/FreePubs/pdfs/uj256.pdf

Sanderson, M.A., and Jones, R.M., 1997. Forage yields, nutrient uptake, soil chemical changes and nitrogen volatilization from bermudagrass treated with dairy manure. J. Prod. Agric. 10:266-271.

Scott, G., and Crunkilton, R.L., 2000. Acute and chronic toxicity of nitrate to fathead minnows (Pimephales promelas), Ceriodaphnia dubia, and Daphnia magna. Environ Tox & Chem 19 (12):2918-2922.

Society for Mining, Metallurgy, and Exploration (SME), 2006. Industrial Minerals and Rocks: commodities, markets, and uses.

Urbansky, E.T., Collette, T.W., Robarge, W.P., Hall, W.L., Skillen, J.M., and Kane, P.F., 2001. Environmental Protection Agency. Survey of Fertilizers and Related Materials for Perchlorate. EPA Doc. No. 600-R-01-047.

USDA, 1995. Technical Advisory Panel Review for Sodium Nitrate, Retrieved February 15, 2011 from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5085204

USDA, 1996. Conservation Crop Rotation Effects on Soil Quality, Natural Resources Conservation Service, Retrieved February 24, 2011 from http://soils.usda.gov/sqi/management/files/sq_atn_2.pdf

USDA, 2002a. Technical Advisory Panel Review of Chilean Nitrate for General Use, Retrieved February 15, 2011 from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5088619

USDA, 2002b. Technical Advisory Panel Review for Chilean Nitrate for use in Spirulina aquaculture production, Retrieved February 15, 2011 from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5088620

USDA, 2010. Guidance: Allowance of green waste in organic production systems, Retrieved March 18, 2011 from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5087122

Vis, K., 2010. The Rise and Fall of Chile's Saltpeter Industry, Retrieved January 21, 2011 from http://www.suite101.com/content/the-rise-and-fall-of-chiles-saltpetre-industry-a220611

Zublena, J.P., Barker, J.C., and Carter, T.A., 1993. Retrieved January 26, 2011 from http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-05/