



Preston Engineering, Inc.

environmental consultants

Corporate Office
4436 N. Brady St. • Davenport, IA 52806
Ph. 319/388/8288 • Fax 319/388/9003
www.prestonengineering.com

Petition for Calcium Oxide as a Synthetic Substance for Organic Crop Production

Prepared By –

Morris L. Preston, P.E.
Preston Engineering, Inc.
4436 North Brady Street
Davenport, Iowa 52806

563/388-8288

563/388-9003 Fax

1. The substance's common name.

Lime

2. The manufacturer's name, address and telephone number.

Meeker Farms Inc.
3659 Riverview Circle
Muscatine, IA 52761

563/323-4404

563/323-8767 Fax

Regional Office
5650 N.W. Johnston Dr. Ste. G • Johnston, IA 50131
Ph. 515/727/9195 • Fax 515/727/9198

3. Intended or current use of the substance.

Calcium Oxide is used in a soluble calcium complex (marketed as Bio-Cal) intended to provide calcium to crops. The material is used to replenish calcium in soils and to facilitate the plant uptake of calcium and other minerals in a soluble form. Calcium oxide is one ingredient in Bio-Cal Calcium Complex which is a source of highly "plant available" calcium and sulfur currently applied to between 50,000 and 100,000 acres annually in the Midwest on crops ranging from alfalfa to cannery vegetables, potatoes and trees. It has been shown to improve yield and uptake of major minerals important to animal nutrition, particularly dairy cows. It is effective at improving soil calcium levels on neutral pH soils.

4. A list of the crop, livestock or handling activities for which the substance will be used.

The substances will be used for crop production such as:

Forage crops like alfalfa, clover, bromegrass, orchard grass, and typical pasture;

Grain crops such as corn, soybeans, oats, barley, and wheat;

Vegetable crops such as potatoes, beans, carrots, peas, and corn;

Trees including fruit trees.

5. The source of the substance and a detailed description of its manufacturing or processing procedures from the basic components to the final product.

The calcium oxide comes from a lime kiln that produces the type of lime used in plants that soften drinking water. A lime kiln produces calcium oxide by heating ground calcitic limestone until carbon dioxide is released from the limestone. The

lime products that do not have the proper particle size or do not have a high enough lime content are used in a proprietary soluble calcium complex. The calcium complex also contains ground limestone and ground gypsum. These ingredients are mixed with water in a multi-step hydration process. Most of the lime combines with water to form calcium hydroxide during the hydration process. The addition of water also forms a larger size particle and reduces dust during handling and field application. While concentrated lime gives off a considerable amount of heat, after hydration the lime does not exert heat when it comes in contact with soil, water or living organisms. The lack of heat generation is supported by field observations and by laboratory tests. The process used by Meeker Farms produces a very stable calcium complex that is beneficial to crops and soil microorganisms.

6. A summary of available previous reviews by State or private certification programs or other organizations of the petitioned substance.

Bio-Cal Calcium Complex which contains calcium oxide has traditionally been accepted and used by local organic chapters affiliated with the Organic Crop Improvement Association and Organic Growers and Buyers Association. It has not been reviewed by national organic standard groups.

A product referred to as Bordeaux mix is synthetic and allowed for use in organic crop production. Bordeaux mix includes copper sulfate and hydrated lime. It is likely that it also contains some calcium oxide that did not convert to calcium hydroxide during the hydration process. Because both Bio-Cal Calcium Complex and Bordeaux mix include hydrated lime the previous review materials for Bordeaux mix would be applicable. Hydrated lime is formed when water is added to lime (calcium oxide). In this process most of the calcium oxide is transformed to calcium hydroxide. However, a small quantity of calcium oxide typically remains in the final product. Archived information supporting the petition for hydrated lime is included in the attachment to this petition.

7. Information regarding EPA, FDA, and State regulatory authority registrations, including registration numbers.

Bio-Cal which contains calcium oxide has been registered with the following State Departments for agricultural use.

<u>State</u>	<u>Registration #</u>
Iowa	00059 002
Illinois	Reciprocity with Iowa
Wisconsin	28-001851

8. The Chemical Abstract Service (CAS) number or other product number of the substance and labels of products that contain the petitioned substances.

The CAS # for calcium oxide is 1305-78-8.

The label for Bio-Cal is included at the end of the petition. Bio-Cal includes calcium oxide.

9. The substance's physical properties and chemical mode of action including (a) chemical interactions with other substances, especially substances used in organic production; (b) toxicity and environmental persistence; (c) environmental impacts from its use or manufacture; (d) effects on human health; and, (e) effects on soil organisms, crops, or livestock.

Pure or 100% calcium oxide is very reactive with water giving off a significant amount of heat.. However calcium complexes with 5 to 10% calcium oxide have proven to be chemically inactive while still providing highly soluble calcium. For instance, Bio-Cal Calcium Complex is a dry granular substance that is chemically

inactive when it comes in contact with water, soil or living organisms. This calcium complex is slightly soluble, up to 10% in water. This solubility allows crop uptake of calcium, sulfur, boron, and trace minerals in the product.

The calcium oxide is not toxic. The calcium is a common mineral found in nature. The calcium oxide in a calcium complex provides minerals that are often deficient in soils.

The lime used in hydrated calcium complexes may be lime that does not meet specifications for some other uses. Typically during the first few hours after the lime kiln is started it produces a mixture of calcium oxide and limestone feed. While this material does not have a high enough lime content for use in water purification, it is fine for a calcium complex. Some lime products are provided in a pebble size. Dust and other undersized particles are screened off. These screenings are also excellent makeup for calcium complexes. Calcium complexes such as Bio-Cal Calcium Complex are a way that lime that does not meet specification for one use can be used beneficially for another use. The end result is a high quality source of calcium at a cheaper cost to the producer. The processes used to manufacture lime and Bio-Cal Calcium Complex meet all environmental regulations.

Observations by producers using calcium complexes containing calcium oxide such as Bio-Cal indicate an increase in earthworms in fields where it has been used. Producers also indicate that crops are more vigorous. Livestock that consume forages from these fields are reported to be healthier. The soluble and highly available form of calcium in Bio-Cal Calcium Complex is taken up by the plant. This also facilitates the uptake of other minerals. Livestock are then able to obtain necessary minerals such as calcium from the forage without the need for mineral supplements. These conclusions are supported by scientific articles and the first hand observations of the many producers who use soluble calcium complexes.

Midwestern Bio-Ag Products and Services located at Blue Mounds, Wisconsin has conducted studies of microorganism levels when Bio-Cal was applied to test plots. The results of these tests indicate that diverse and vigorous natural microorganisms existed in plots that received Bio-Cal applications. A report titled "Effect of Bio-Cal and Other Common Calcium Soil Supplements on Biological Activity in Soil" is included with the petition.

An article titled "Why Bio-AG fertilizers?" in Bio-News, Fall 2000, Volume 5, Issue 4, explains the benefits of fertilizers such as Bio-Cal. This article is attached to the petition. The book "The Biological Farmer" by Gary F. Zimmer discusses the beneficial aspects of Bio-Cal. Chapter 10 - Liming and pH discusses the advantages of Bio-Cal which is effective at providing calcium when soil pH levels are near neutral and pH adjustment is not necessary.

A supporting document - "Typical Effect of Bio-Cal Soil Application on Subsequent Mineral Supplement Purchase for Dairies" by William A. Zimmer D.V.M. is attached. This study looked at Bio-Cal which is a product containing calcium oxide. This study looked at the mineral content of 295 samples of forages grown on land that had received applications of Bio-Cal. These tests were compared to typical levels found in forages. Fields receiving Bio-Cal grew forages with a higher digestible mineral content. This results in a substantial reduction in the amount of mineral supplements that must be added to the cow's diet. In one example a 50 cow dairy herd could save over four tons of mineral supplement in one year.

Laboratory analyses for major and trace substances found in Bio-Cal are attached. A laboratory report is also attached that demonstrated that Bio-Cal does not give off heat when water is added.

Perhaps the strongest evidence of benefits of soluble calcium complexes is the ardent support received from producers that have seen the results. They report better forages and healthier livestock. Producer comments are also attached.

10. Safety information about the substance including a material data safety sheet (MSDS) and a substance report from the National Institute of Environmental Health Studies.

The MSDS sheets are attached for calcium oxide and Bio-Cal which is a calcium complex containing calcium oxide. A side by side review of these two documents indicates that while concentrated calcium oxide is a harsh and reactive chemical, calcium complexes such as Bio-Cal which contains up to 10% calcium oxide are not reactive or harmful.

Calcium oxide was researched through various government clearinghouses and web sites. This literature discusses the pure form of calcium oxide, not the stable form in calcium complexes such as Bio-Cal. Available information is attached. Calcium oxide has not been nominated or chosen for testing by the National Toxicology Program. Envirofacts from the EPA website were obtained for calcium oxide. It is a strong base in pure concentrated form. This characteristic is however not observed in Bio-Cal Calcium Complex.

11. Research information about the substance which includes comprehensive substance research reviews and research bibliographies which present contrasting positions to those presented by the petitioner in supporting the substance's inclusion on or removal from the National List.

The paper "Effect of Bio-Cal and Other Common Calcium Soil Supplements on Biological Activity in Soil" by Midwestern Bio-Ag Products and Services is attached. This study was designed to demonstrate the effects of three common calcium sources – calcitic limestone (calcium carbonate), burnt lime (calcium oxide) and Bio-Cal (calcium complex) – on soil microbiology. The disintegration rate of cotton strips was used to simulate the effects on microorganisms responsible for crop residue recycling. Production of a known metabolite of soil microorganisms, formazan enzyme, was used as a second measure of soil microbiology. Finally, enumeration of specific

classes of soil microorganisms was used to determine whether any detrimental effect was seen on normal microbial diversity. Results from the study show no detrimental effect on soil microbial activity when the calcium complex found in Bio-Cal is applied to soil. Considering that, one can conclude that the calcium complex in Bio-Cal is safe for soil organisms.

The paper "Comparison of Bio-Cal and Other Common Calcium Soil Supplements on Soil Fertility and Tissue Analysis of Soybeans" by Midwestern Bio-Ag Products and Services is attached. The study demonstrates the effects of three common calcium sources – calcitic limestone (calcium carbonate), gypsum (calcium sulfate) and Bio-Cal (calcium complex) – on soil fertility and plant tissue mineral analyses. The results of the study show that soil calcium and phosphorous as well as plant tissue calcium and phosphorous were higher in fields receiving Bio-Cal Calcium Complex. Bio-Cal is the best source of 'plant available' calcium at soil pH levels common to most agronomic systems in North America (pH between 6.5 and 7.0). The study shows Bio-Cal raises soil calcium levels better than limestone or gypsum at neutral pH. This increased soil calcium was shown to directly relate to higher plant calcium. Since plants are the major source of calcium for livestock, Bio-Cal applied to the soil can indirectly improve animal nutrition and the economics of balancing animal rations. Although Bio-Cal is not a source of phosphorous, soil phosphorous was consistently highest where Bio-Cal was applied. Bio-Cal's ability to increase soil phosphorous fertility and subsequent plant phosphorous levels are both beneficial attributes. Increased plant phosphorous levels will reduce the cost and waste of phosphorous supplementation in animal diets.

The book "The Biological Farmer" by Gary F. Zimmer is a guide to the sustainable and profitable biological system of farming. Chapter 10 'Liming & pH' is attached. The book explains that calcium "*improves soil structure, thus increasing aeration which is vital for good root growth and beneficial forms of soil life. Higher levels of soil calcium increase availability of other plant nutrients by such mechanisms as raising the soil's CEC and buffering capacity, increasing root growth and increasing*

microbial release of tied-up nutrients.” This book discusses various sources of calcium including limestone and gypsum. Limestone releases calcium as the carbonate neutralizes soil acid. The calcium bond in calcium carbonate is strong relative to other calcium bonds. For this reason, limestone is only a good source of ‘plant available’ calcium under acidic soil conditions. Gypsum on the other hand has shown good results on alkaline soils. Gypsum is probably best suited as an amendment on very alkaline soils as it’s sulfur will tend to decrease soil pH. Bio-Cal is able to provide calcium at a neutral pH. The book also discusses case histories where various materials including Bio-Cal have been used to increase soil fertility.

An article “Why Bio-Ag fertilizers” published in BIO-NEWS, fall 2000 discusses considerations in the selection of fertilizers. Bio-Cal is often a good choice because it has significant levels of soluble calcium.

An article “Why Bio-Cal” published in BIO-News, Volume 5, Issue 3 discusses the benefits of Bio-Cal. One of the major benefits is that Bio-Cal has a high level of soluble calcium (150 pounds per ton) and it is effective at all soil pHs.

An article “Improved Potato Yields, Quality and Profits Through Calcium” by Melissa Lake, published in the October, 2000 issue of the Badger Commentator explains the benefits of Bio-Cal when applied to potato crops. Bio-Cal applications were reported to increase mineral uptake by the potatoes.

A supporting document –“Typical Effect of Bio-Cal Soil Application on Subsequent Mineral Supplement Purchase for Dairies” by William A. Zimmer D.V.M. is attached. This study looked at Bio-Cal which is a product containing calcium oxide. This study looked at the mineral content of 295 samples of forages grown on land that had received applications of Bio-Cal. These tests were compared to typical levels found in forages. Fields receiving Bio-Cal grew forages with a higher digestible mineral content. This results in a substantial reduction in the amount of mineral

supplements that must be added to the cows diet. In one example, a 50 cow dairy herd could save over four tons of mineral supplement in a years time.

Numerous endorsements from producers who use Bio-Cal calcium complex are attached. The producers express their positive experiences with Bio-Cal. They cite healthier soils, healthier crops, healthier livestock, and increased biological activity in soils where Bio-Cal has been applied.

Ms. Zea Sonnabend provided archived information for hydrated lime which has been approved for use in Bordeaux mix. This information includes the hydrated lime data base and references.

12. A "Petition for Justification Statement" which provides justification for the inclusion of a synthetic substance on the National List. The petition should state why the synthetic substance is necessary for the production of organic crops. The petition should also describe the nonsynthetic substance could be used in its place. Additionally, the petition should summarize the beneficial effects to the environment, human health, or farm ecosystem from use of the synthetic substance that support the use instead of the use of the nonsynthetic substance.

Lime is a source of highly 'plant available' calcium if it is properly formulated in a calcium complex such as Bio-Cal. Bio-Cal has been shown to improve yield and uptake of major minerals important to animal nutrition. It has been shown to improve soil calcium levels even on neutral pH soils. The calcium oxide portion of Bio-Cal Calcium Complex provides a stable material with high calcium solubility. Commonly available natural limestone and gypsum will not release significant quantities of calcium at neutral soil pH conditions often found in agricultural fields. Limestone releases calcium in acid soils when the carbonate reacts with the acid hydrogen radical. This reaction raises the pH and releases calcium in acid soils. Gypsum on the other hand releases calcium in alkaline soils

where the sulfate reacts with the alkalinity in the soil and thus lowers pH and releases calcium. Bio-Cal calcium complex is much more effective at releasing calcium at soil pH levels common to most agronomic systems in North America (pH between 6.5 and 7.0).

The paper by William Zimmer discusses the increase of calcium uptake when Bio-Cal Calcium Complex is applied to fields. The plants not only have more calcium, they have more digestible calcium. Data published by William A. Zimmer indicates that forages treated with Bio-Cal had higher levels of calcium, phosphorous, magnesium, potassium, and sulfur. These are the five major minerals typically supplemented in dairy rations. The higher levels of soluble minerals in the forage makes dairy animals healthier and reduces the amount of mineral supplement required. The lime content of Bio-Cal is important in providing an immediate boost to available calcium in mineral deficient soils. The other calcium compounds are generally slower release and supply calcium over a longer time period. Calcium uptake also facilitates the uptake of other minerals such as copper, manganese, silica, and zinc.

Bio-Cal undergoes a proprietary process to produce a thoroughly hydrated product in a readily spreadable form using standard lime spreading equipment. The major processing occurs via hydration with ordinary water and mechanical operations. Bio-Cal does not have the highly caustic characteristics of burnt lime (quick lime). While Bio-Cal does contain highly available and soluble calcium in the forms of calcium hydroxide, calcium sulfate, calcium carbonate, and some calcium oxide, it does not have the negative effects on microorganisms of hydrated or burnt lime. Testing shows that while calcium oxide gives off heat when water is added, the calcium oxide in Bio-Cal does not yield measurable amounts of heat when water is added. The aforementioned characteristics make Bio-Cal a superior product to ordinary quarried limestone or gypsum, without the concerns or risks of unhydrated or partially hydrated and highly caustic products such as burnt lime.

The following article entitled "Why Bio-Cal?" from Bio-News provides an excellent justification for the use of Bio-Cal Calcium Complex.

Why Bio-Cal?

"Calcium is the key to building soil fertility," says Gary Zimmer.

Why is Calcium important?

Even though it is called a secondary element, calcium has many important functions.

- Calcium is needed at high levels by plants. Plants need a continuous supply of calcium for growth and quality. It is a vital element in plant growth and health, involved in building cell walls and cellular membranes, cell division, and preventing invasion by disease pathogens.

- Calcium stimulates beneficial soil organisms, including earthworms and microorganisms such as bacteria actinomycetes and fungi.

- Calcium improves soil structure. It loosens soil and causes the tiny soil particles to aggregate or clump together. Aggregated soils have more pore space, so they hold water and air better. They drain better and absorb moisture faster, reducing erosion; are easier to till; and reduce compaction.

- "The trucker of all minerals," calcium makes other nutrients more available. It raises the CEC or Cation Exchange Capacity, a measure of the soil's ability to store and release nutrients.

- Midwestern Bio-Ag recommends ideal calcium levels of 1,500-2,000 ppm or higher, as well as Calcium to Magnesium (Ca to Mg) levels of 5:1 to 7:1.

Why is additional calcium needed?

In the midwest, calcium is often a limiting factor. Leaching moves calcium out of the root zone. Overuse of nitrogen and/or salt fertilizers leads to acidity or ties-up the calcium.

Legume crops can take from 100-250 lbs./acre per year of calcium, corn and grass crops 15-40.

Even soils that show adequate calcium on standard tests may not have enough readily available calcium for optimum plant growth all season long.

Most commonly used liming materials contain calcium, so the myth has grown that calcium neutralizes acidity. That is not true. The most important result of liming soil is not neutralizing acidity but replacing the nutrients that have been depleted by crops or lost via leaching.

What is Bio-Cal

Bio-Cal, a proprietary product of Midwestern Bio-Ag, is a liming material and soil corrective that supplies significant amounts of readily available calcium, sulfur and other nutrients required to grow healthy, yielding crops. Bio-Cal contains 28-36 percent calcium, plus 6-12% sulfur, and boron.

It is made from high quality sources of slaked lime, quarried gypsum (calcium sulfate), and quarried limestone (calcium carbonate). The special blending and hydration process changes and improves the characteristics of the raw materials. Processing changes some of the calcium into a highly available form of calcium, calcium hydroxide. Bio-Cal also contains calcium in the form of calcium silicate, calcium sulfate and calcium carbonate. This combination gives us desirable levels of both highly available and slow release calcium. The raw materials are all blended, crushed and screened.

Bio-Cal meets all established levels set by state and federal agencies for all contaminants (heavy metals, dioxins and other compounds) for land applied products. Tested extensively, Bio-Cal has been found to be very clean compared to other byproducts, and is as safe or safer than naturally mined materials.

What is the history of Bio-Cal?

Midwestern Bio-Ag developed the Bio-Cal product as the best calcium source on the market over 15 years ago. Since then well over 200,000 tons have been applied to farm fields with excellent results. The product has been

refined over the years as well, and although alternative products have popped up in the marketplace, nothing has performed as consistently in getting calcium to plants.

How is Bio-Cal different from other products?

Bio-Cal contains calcium in a form that is highly soluble and readily available to plants. Research indicates up to 150 lbs. of soluble calcium per ton of Bio-Cal, compared to quarried limes with 5 lbs. or less per ton.

By comparison, high calcium lime is slower acting, requires more and often is not locally available. Dolomitic lime is hard stone and slow (up to 18 months) to become available to the plant, and contains high magnesium. Papermill sludge, where available, is hard to handle and often not sufficiently processed. Liquid lime is more expensive. Additionally, gypsum shouldn't be used on low pH soils, if calcium base saturation is less than 60%

Midwestern Bio-Ag does not recommend that any client use unprocessed kiln byproducts that contain high amounts of calcium oxide. These can have deleterious effects on soil and crops. Do not confuse quick lime or burnt lime with Bio-Cal.

One feed test study on the value of using Bio-Cal was conducted in 1995-97, comparing results from 295 MBA Fertility Program (including the use of Bio-Cal) haylage samples versus 35,000 other samples tested by Dairyland Labs over two years. The MBA farms showed calcium levels 47% above the others, at 1.62 (meeting the MBA desired feed test level of 1.3 or above) vs averages of 1.10 and 1.15 on conventional farms. MBA farms also averaged higher in phosphorus (by 16%), magnesium (by 32%), sulfur (by 29%), and potassium (by 11%).

Bio-Cal is an excellent and proven product for farmers who want to increase the amount of available calcium in their soils and in their crops. For more information about Bio-Cal, contact MBA at 1-800-327-6012.

The literature and articles presented in this petition clearly indicates the value of calcium as a mineral in soil and as a plant and animal nutrient. Calcium is prevalent in soil and water and is present in all living organisms. Water for instance contains mineral forms of calcium such as calcium carbonate, calcium oxide and calcium hydroxide. A complete ban of calcium hydroxide would prohibit irrigation of crops or watering of livestock with anything but distilled water. Clearly the issue is the form and manner in which calcium compounds such as calcium oxide and calcium hydroxide are applied to soils. Years of on the farm trials have established that calcium complexes such as Bio-Cal contribute to remineralization of soils, healthy crops, and healthy livestock.

13. A Commercial Confidentiality Statement (if desired).

The process used to produce Bio-Cal Calcium Complex is proprietary. While the information in this petition is not considered confidential, supplemental information requested by the board in the future may be considered confidential.

Requested Action

We are requesting that calcium oxide (lime) be approved as a restricted use synthetic material for use in organic crop production with the following conditions:

It is applied in a form that yields less than 1 degree Fahrenheit temperature increase when equal volumes of product and water are mixed.

It is applied to fields in amounts necessary to raise soil minerals to optimum levels based on soil tests.

It is applied as part of a managed program to re-mineralize soils.

Attachments: Bio-Cal label

Material Safety Data Sheet – Bio-Cal

Material Safety Data Sheet – Calcium Oxide

State Registrations

Chemical Analysis

Toxicology information for Calcium Oxide

Hydrated Lime Data Base and References

Articles: Effect of Bio-Cal and Other Common Calcium Soil Supplements on
Biological Activity in Soil

Typical Effect of Bio-Cal Soil Application on Subsequent Mineral
Supplement Purchase for Dairies

Comparison of Bio-Cal and Other Common Calcium Soil
Supplements on Soil Fertility and Tissue Analysis of Soybeans

Why Bio-Ag Fertilizers?

Why Bio-Cal?

Nutrition from the Soil Up

Improve Potato Yields, Quality and Profits Through Calcium

Test Plots Show Not All Calcium Is the Same

The Biological Farmer-Liming and pH

Producer Survey Forms

TM

BIO-CAL

To Be Applied as a Liming Material.

Ingredients

Bio-Cal is a stable, fully hydrated, proprietary blend of lime kiln dust, fluidized bed ash, calcitic burnt lime, mined calcium sulfate (gypsum) and mined calcitic limestone.

This product contains the byproducts lime kiln dust and fluidized bed ash, which have met the criteria for agricultural use as set forth by the State of Minnesota Pollution Control Agency as defined under MPCA permit # ???????

Proximate Analysis

Neutralizing Index Zone	less than 40
Total Calcium	30 - 35 %
Available Calcium (hydroxide form)	10 - 20 %
Sulfur	4 - 6 %

Also supplies agronomically significant amounts of boron and manganese.

Application Rate

Typical application rate is 500 to 1000 pounds per acre, and should be based on a soil test.

Midwestern Bio-Ag Products and Services
PO Box 160, Hwy. ID, Blue Mounds, WI 53517
1 (608) 437-4994

Material Safety Data Sheet

Midwestern Bio-Ag
P.O. Box 160
Blue Mounds, WI 53517
800-327-6012

Date Printed: 09/09/97

Information on this data sheet are compiled from analysis of materials and records from the manufacturer of this material. This information is believed to be accurate and reliable and it is provided for your use and consideration. Information accuracy is not implied nor guaranteed and Midwestern Bio-Ag assumes no responsibility for accuracy or completeness. The user is responsible for the proper use, storage and disposal of the material.

Section 1: General Information

Product Name: Bio-Cal

Other Names: Ag-liming agent.

Description: Bio-Cal is manufactured from natural and man-made ingredients and is composed primarily of calcium hydroxide, calcium sulfate and calcium carbonate with minor amounts of other minerals and is characterized as inorganic in nature. The product is used by the farming community as a soil additive and provides necessary elements and minerals needed by the soil.

Section 2: Ingredients

<u>Component Name</u>	<u>% Found</u>
Silicon	0.5-2
Aluminum	0.1-0.5
Iron	0.2-0.5

Calcium	65-85
Magnesium	0.5-1
Sulfur	3.5-5
Potassium	0.1-1
Carbon	6-8
Moisture	10-15

Section 3: Physical Properties

Boiling Point: N/A	Vapor Pressure: N/A
Vapor Density: N/A	Specific Gravity: 2.5-2.8
Melting Point: >2500 Deg. F	Evaporation Rate: N/A
Odor: Earthy	Appearance: Light to dark granular
Volatiles: 7-8%	Moisture: 10-15%
pH: 11-12	Heat Value: <1000 BTU/#

Solubility in Water: Up to 10% solubility, which increases over time.

Section 4: Fire, Chemical, and Explosion Data

Flash Point: ND Autoignition Temp.: ND LEL: ND UEL: ND

Extinguishing Media: Not required

Decomposition Products: This product may be slightly combustible due to the presence of carbon. Decomposition products may include carbon monoxide, nitrogen oxides.

Special Fire Fighting Procedures: Not required

Unusual Fire and Explosion Hazards: None

Section 5: Health Hazard Information

Silicon dioxide: Exposure to high levels of airborne crystalline silica can lead to a condition called acute silicosis with symptoms of coughing, shortness of breath. Acute silicosis can be fatal. Long term exposures may lead to scarring of the lung tissue. Crystalline silica is listed by NTP and IARC as a carcinogen. This product generally contains less than one percent of total silica and should not pose any problems, but inhalation precautions should be taken as with any fine particulate material.

Aluminum, Iron, Calcium, Magnesium, Sulfur, Potassium and Carbon: These chemicals represent low risk health hazards. Their primary risk is associated with inhalation as a nuisance dust.

Inhalation: Breathing dust may cause nose, throat or lung irritation and choking. The described effect depends on the degree of exposure.

Eye Contact: May cause eye irritation and damage to cornea.

Skin Contact: May cause dry skin, redness, discomfort or irritation.

Ingestion: Ingestion of large amounts may cause intestinal distress.

Section 6: Emergency and First Aid Procedures

Handle in accordance with good hygiene and safety practices. These practices include avoiding unnecessary exposure of the material to the eyes, skin and clothing.

Eye Contact: If the eyes become exposed the eyelids should be held open and the eyes irrigated for at least 15 minutes with running water.

Skin Contact: Generally this is not a problem, but if irritation occurs wash the effected area.

Inhalation: Move the person to fresh air. If breathing difficulty occurs administer rescue breathing or CPR and seek medical attention.

Ingestion: Do not induce vomiting, give large quantities of milk or water if conscious and seek medical attention.

Clothing: Wash with a mixture of acetic acid (vinegar) and water if clothing becomes soiled with Bio-Cal.

Section 7: Employee Protection Information

Eye Protection: Wear dust proof goggles if eye contact is suspected.

Skin Protection: Wear gloves when handling.

Respiratory Protection: Avoid unnecessary exposures to dust. Use NIOSH/MSHA approved equipment when airborne exposures are expected to exceed exposure guidelines or standards.

Ventilation: Provide ventilation to minimize exposure.

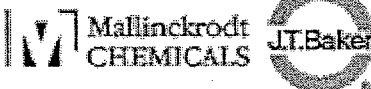
Section 8: Spill, Leak and Disposal Information

This product supplied by Midwestern Bio-Ag is not a hazardous waste as defined in 40 CFR 261, "Identification and Listing of Hazardous Waste".

If a spill occurs this product may be disposed in a landfill in accordance with all applicable regulations.

MSDS Material Safety Data Sheet

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865



24 Hour Emergency Telephone: 908-656-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-696-6666

Outside U.S. and Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-852-2537) for assistance.

CALCIUM OXIDE

MSDS Number: C0462 --- Effective Date: 09/15/98

1. Product Identification

Synonyms: Lime unslaked; lime burnt; quicklime; calx; lime purified
CAS No.: 1305-78-8
Molecular Weight: 56.08
Chemical Formula: CaO
Product Codes:
J.T. Baker: 1410, 1414
Mallinckrodt: 0204, 4243, 4248

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Calcium Oxide	1305-78-8	100%	Yes

3. Hazards Identification

Emergency Overview

DANGER! CAUSES SEVERE IRRITATION AND BURNS TO EVERY AREA OF CONTACT. HARMFUL IF SWALLOWED OR INHALED.

J.T. Baker SAF-T-DATA^(tm) Ratings (Provided here for your convenience)

Health Rating: 1 - Slight
Flammability Rating: 0 - None

Reactivity Rating: 1 - Slight
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES; LAB COAT
Storage Color Code: Orange (General Storage)

Potential Health Effects

Inhalation:

Inhalation of dust is highly irritating and possibly corrosive to the upper respiratory tract. May cause coughing, sneezing, labored breathing, and possibly burns with perforation of the nasal septum.

Ingestion:

Corrosive. May attack the esophagus. Abdominal pain, nausea, vomiting may result. May cause serious alkali burns in mouth and throat.

Skin Contact:

Irritant; may cause severe corrosive damage.

Eye Contact:

Severe irritant, may damage eye tissues. Causes redness, tearing, blurred vision, pain.

Chronic Exposure:

Chronic inhalation of dust may cause inflammation of the respiratory passages, ulcers of the mucous membranes, and possible perforation of nasal septum.

Aggravation of Pre-existing Conditions:

Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

4. First Aid Measures

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion:

DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:

Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician, immediately. Wash clothing before reuse.

Eye Contact:

Wash thoroughly with running water. Get medical advice if irritation develops.

5. Fire Fighting Measures

Fire:

Not considered to be a fire hazard. Lime and water can react exothermically with sufficient heat to ignite combustible materials in certain instances.

Explosion:

Not considered to be an explosion hazard. The combination of lime and water at high temperatures may be explosive.

Fire Extinguishing Media:

Use any means suitable for extinguishing surrounding fire.

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust.

7. Handling and Storage

Keep in a tightly closed container. Protect from physical damage. Store in a cool, dry, ventilated area away from sources of heat, moisture and incompatibilities. This strongly alkaline material will swell and generate heat when moistened and could burst container. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:

-OSHA Permissible Exposure Limit (PEL):

5 mg/m³ (TWA).

-ACGIH Threshold Limit Value (TLV):

2 mg/m³ (TWA)

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded, a full facepiece respirator with dust/mist filter may be worn up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. **WARNING:** Air purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:

Use chemical safety goggles and/or full face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:

White to slightly yellowish powder.

Odor:

Odorless.

Solubility:

Slightly soluble in water with release of heat, formation of calcium hydroxide.

Specific Gravity:

3.37

pH:

12.5 Saturated solution in water

% Volatiles by volume @ 21C (70F):

0

Boiling Point:

2850C (5162F)

Melting Point:

2572C (4662F)

Vapor Density (Air=1):

1.9

Vapor Pressure (mm Hg):

No information found.

Evaporation Rate (BuAc=1):

No information found.

10. Stability and Reactivity

Stability:

Stable at room temperature in sealed containers.

Hazardous Decomposition Products:

No hazardous decomposition products.

Hazardous Polymerization:

Will not occur.

Incompatibilities:

Water, acids, humid air, hydrogen fluoride, phosphorous pentoxide, boric oxide, steam, many organic substances.

Conditions to Avoid:

Air, moisture, and incompatibles.

11. Toxicological Information

Ingredient	---NTP Carcinogen---		IARC Category
	Known	Anticipated	
Calcium Oxide (1305-78-8)	No	No	None

12. Ecological Information

Environmental Fate:

No information found.

Environmental Toxicity:

This material is expected to be toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

International (Air, I.C.A.O.)

Proper Shipping Name: CALCIUM OXIDE

Hazard Class: 8

UN/NA: UN1910

Packing Group: III

Information reported for product/size: 100LB

15. Regulatory Information

-----\Chemical Inventory Status - Part 1\-----				
Ingredient	TSCA	EC	Japan	Australia
Calcium Oxide (1305-78-8)	Yes	Yes	Yes	Yes

-----\Chemical Inventory Status - Part 2\-----				
Ingredient	Korea	DSL	NDL	Phil.
Calcium Oxide (1305-78-8)	Yes	Yes	No	Yes

-----\Federal, State & International Regulations - Part 1\-----				
Ingredient	-SARA 302-		-SARA 313-	
	RQ	TPQ	List	Chemical Catg.
Calcium Oxide (1305-78-8)	No	No	No	No

-----\Federal, State & International Regulations - Part 2\-----			
Ingredient	CERCLA	-RCRA-	-TSCA-
		261.33	8(d)
Calcium Oxide (1305-78-8)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No

SARA 311/312: Acute: Yes Chronic: Yes Fire: No Pressure: No
Reactivity: Yes (Pure / Solid)

Australian Hazchem Code: No information found.

Poison Schedule: No information found.

WHMIS:

This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: 1 Flammability: 0 Reactivity: 1

Label Hazard Warning:

DANGER! CAUSES SEVERE IRRITATION AND BURNS TO EVERY AREA OF CONTACT. HARMFUL IF SWALLOWED OR INHALED.

Label Precautions:

Do not get in eyes, on skin, or on clothing.

Do not breathe dust.

Keep container closed.

Use only with adequate ventilation.

Wash thoroughly after handling.

Label First Aid:

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases call a physician.

Product Use:

Laboratory Reagent.

Revision Information:

MSDS Section(s) changed since last revision of document include: 14.

Disclaimer:

Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. MALLINCKRODT BAKER, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, MALLINCKRODT BAKER, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.

Prepared by: Strategic Services Division

Phone Number: (314) 539-1600 (U.S.A.)

Wisconsin Department of Agriculture,
Trade and Consumer Protection
PO BOX 8911, MADISON, WI 53708-8911

NUMBER:
28-001851-001851

LIME LICENSE

s. 94.66, Wis. Statutes

LICENSED BUSINESS LOCATION

MIDWESTERN BIO-AG PRODUCTS & SERVICES INC
10851 COUNTY ROAD ID
BLUE MOUNDS WI

EXPIRES:
12/31/00

SUBJECT TO REVOCATION
AS PROVIDED BY LAW

MAIL ADDRESS

MIDWESTERN BIO-AG PRODUCTS & SERVICES INC
ATTN GARY ZIMMER
PO BOX 160
BLUE MOUNDS WI 53517

DOING BUSINESS AS:

THIS LICENSE IS NOT TRANSFERABLE

POST OR CARRY AS REQUIRED BY LAW

MINNESOTA DEPARTMENT OF AGRICULTURE

90 WEST PLATO BOULEVARD, ST. PAUL, MINNESOTA 55107-2094

LICENSE / CERTIFICATION

AGRICULTURAL LIMING MATERIAL LICENSE

MIDWESTERN BIO-AG PRODS & SVCS INC
HWY ID
P O BOX 126
BLUE MOUNDS, WI 53517

ID: 012601
VOLUME CERT: NO

License/Certification Categories

DISTRIBUTOR

20030448

\$150.00

Lic./Cert. No. Lic./Cert. Fee Paid

This license must be posted in a conspicuous place and is not transferable.

AKI-00853-04 In accordance with the Americans With Disabilities Act, an alternative form of communication is available on request.

POST IN CONSPICUOUS PLACE

NONTRANSFERABLE

STATE OF IOWA

DEPARTMENT OF AGRICULTURE & LAND STEWARDSHIP

DES MOINES

\$25.00

LM 00059 002

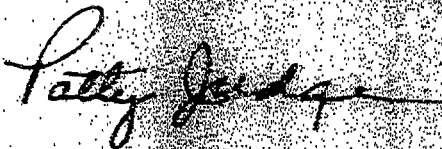
AGRICULTURAL LIMESTONE QUARRY LICENSE

LIMESTONE MINING
MEEKER FARMS INC
BUFFALO IA

THE AFORESAID, HAVING DEPOSITED THE REQUIRED FEE, IS HEREBY GRANTED THE ABOVE LICENSE PURSUANT TO CHAPTER 201A, CODE OF IOWA. THIS LICENSE SHALL REMAIN IN FULL FORCE FROM THE DATE OF ISSUE UNTIL ITS EXPIRATION DATE, UNLESS REVOKED OR SUSPENDED FOR CAUSE BY THE SECRETARY OF AGRICULTURE FOR NONCOMPLIANCE WITH CHAPTER 201A, CODE OF IOWA OR RULES PROMULGATED PURSUANT THERETO.

PRINTED: March 9, 2000

EXPIRES: January 1, 2001



SECRETARY OF AGRICULTURE

003976

***** AGLIME FORMULA WORKSHEET AND CERTIFICATION NOTICE *****

IOWA DEPARTMENT OF AGRICULTURE & LAND STEWARDSHIP
 Henry A. Wallace Building
 Des Moines, IA 50319
 (515) 281-8596

**00059
 MEEKER FARMS INC
 3659 RIVER VIEW CIRCLE
 MUSCATINE IA 52761**

**00059 002
 LINWOOD MINING
 City: BUFFALO, IA
 County: 82-SCOTT
 Township: BUFFALO
 Section: 014**

Pile: **LINWOOD MINING A**

Date Reported	Sample Number	% Finer #4-MESH	% Finer #8-MESH	% Thru 60-MESH	% CaCO ₃	% MOIST	Cert. Value
1) 2000/05/23	00055	94	82	38	97	14	948
2) 2000/04/12	00080	87	75	28	76	15	620
3) 2000/03/23	00037	87	77	35	77	14	699
4) 1999/11/24	00111	85	75	33	75	13	663
5) 1999/10/26	00194	90	83	40	79	16	768

Number of pounds of effective CaCO₃ per ton of aglime as of 06/01/2000 = 740

Sample Certification Computation:

- + Fineness through 4 Mesh (% Thru 4 MESH) X 1)
- + Fineness through 8 Mesh (% Thru 8 MESH) X 3)
- + Fineness through 60 Mesh (% Thru 60 MESH) X 25)

- = Fineness Factor
- X % CaCO₃

- = % of Effective Limestone
- X (100- % Moisture)
- X 2000

- = Sample Certification Value

Notes:
 Sample Certification Value is the number of pounds of effective CaCO₃ per ton of aglime.
 Pile Certification Value is the average of the sample certification value(s).

Q.C. METALLURGICAL LABORATORY, INC.

Mechanical Testing • Metallographers • Chemical Analysis • Consultants

17048 215th Street, Davenport, Iowa 52804

(563) 386-7827 or (563) 386-8739 • FAX (563) 386-6780

June 19, 2001

To: Meeker Farms
Butch Meeker

Report # 19374

Sample Description: "Dry Dust"

Date Received: 06-18-2001

Date Analyzed: 06-19-2001

RESULTS:

We were unable to find an ASTM procedure for determining heats of reaction, so we referred to college chemistry and physics textbooks.

We set up the experiment using an insulated flask, stirring motor, and a certified traceable thermometer. Two hundred milliliters of deionized water and 100grams of the "Dry Dust" sample (both initially at 25 degrees centigrade) were mixed in the calorimeter, and the temperature was observed.


In general, it takes one calorie to raise the temperature of one gram of water one degree centigrade. However, when a substance is added to the water which changes the temperature through an exothermic chemical reaction, some of the heat released is absorbed by solution, and some is absorbed by any material which did not dissolve.

Trying to account for all of the details in this experiment would be extremely difficult. In this experiment, we are simply going to compare results to a similar test performed on Bio-Cal.

100g "Dry Dust" caused less the temperature of the 300g mixture to rise to 60 degrees centigrade over an extended period of time. Because some heat would be lost due to our non-ideal conditions, we will refer to the temperature change as a minimum of 35 degrees.

This roughly calculates to a *minimum* of 105 calories per gram of the "Dry Dust". Bio-Cal roughly had a *maximum* of 0.6 calories per gram, and would have probably been less had we had a sensitive enough thermometer.

John O. Bloodsworth, P.E.


David A. Webb/Chemist

February 29, 2000

To: Meeker Farms
Butch Meeker

Report # 17695

Sample Description: Bio-Cal

Sample Container: Plastic Bag

Date Sampled: 02-24-2000

Date Received: 02-24-2000

Date Analyzed: 02-29-2000

Analyte	Concentration (% by weight)	Method
Aluminum	0.40	EPA 202.1
Calcium	26.29	EPA 215.1
Carbon	5.32	ASTM E1019
Iron	0.50	EPA 236.1
Magnesium	0.95	EPA 242.1
Potassium	0.034	EPA 258.1
Silicon	0.54	SM 3111D
Sulfur	2.18	ASTM E1019
Available CaO	3.88	ASTM C25
Available Fe2O3	0.71	
Available K2O	0.041	
Moisture	15.5	EPA 160.3
pH	13.21	EPA 150.1

John O. Bloodsworth, P.E.

David A. Webb/Chemist

October 5, 1999

To: Meeker Farms
Butch Meeker

Report #17184

Subject: One bag of Bio - Cal for analysis.

<u>Element</u>	<u>Bio-Cal</u>	<u>Methods</u>
Aluminum	0.54	EPA 202.1
Iron	0.43	EPA 236.1
Potassium	0.0198	EPA 258.1
Magnesium	0.10	EPA 242.1
Silicon	1.08	SM 311 D
Carbon	4.15	ASTM E 1019
Sulfur	4.20	ASTM E 1019
Calcium	63.50	SM 2340 C
CaO Available	12.68	ASTM C 25
K ₂ O Available	0.024	EPA 258.1
Fe ₂ O ₃ Available	0.61	EPA 236.1
% Moisture	11.78	EPA 160.3
pH (units)	12.194	EPA 150.1

*all results in weight percent unless otherwise noted.

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

June 11, 1999

To: Meeker Farms
Butch Meeker

Report #16841

Subject: One bag of Bio - Cal and one bag of Sol-U-Cal for analysis.

<u>Element</u>	<u>Bio-Cal</u>	<u>Sol-U-Cal</u>	<u>Methods</u>
Aluminum	0.50	0.13	EPA 202.1
Iron	0.50	0.18	EPA 236.1
Potassium	0.03	0.02	EPA 258.1
Magnesium	0.44	0.26	EPA 242.1
Silicon	0.76	0.18	SM 311 D
Carbon	4.23	4.97	ASTM E 1019
Sulfur	5.10	7.20	ASTM E 1019
Calcium	11.45	26.95	SM 2340 C
CaO Available	12.14	3.94	ASTM C 25
K ₂ O Available	0.04	0.02	EPA 258.1
Fe ₂ O ₃ Available	0.72	0.26	EPA 236.1
% Moisture	13.26	9.81	EPA 160.3
pH (units)	12.230	12.330	EPA 150.1

*all results in weight percent unless otherwise noted.

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

April 12, 1999

To: Meeker Farms
Butch Meeker

Report #16632

Subject: One bag of Bio - Cal and one bag of Sol-U-Cal for analysis.

<u>Element</u>	<u>Bio-Cal</u>	<u>Sol-U-Cal</u>	<u>Methods</u>
Aluminum	0.28	0.05	EPA 202.1
Iron	0.53	0.14	EPA 236.1
Potassium	0.04	0.028	EPA 258.1
Magnesium	0.58	0.25	EPA 242.1
Silicon	0.84	0.17	SM 311 D
Carbon	4.22	6.67	ASTM E 1019
Sulfur	3.90	6.21	ASTM E 1019
Calcium	25.50	47.70	SM 2340 C
CaO Available	13.90	4.98	ASTM C 25
K ₂ O Available	0.05	0.033	EPA 258.1
Fe ₂ O ₃ Available	0.75	0.21	EPA 236.1
% Moisture	13.93	0.09	EPA 160.3
pH (units)	12.398	12.171	EPA 150.1

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

June 22, 1999

To: Meeker Farms
Butch Meeker

Report #16841

Subject: One bag of Bio - Cal and one bag of Sol-U-Cal for analysis.

<u>Element</u>	<u>Bio-Cal</u>	<u>Sol-U-Cal</u>	<u>Methods</u>
Aluminum	0.50	0.13	EPA 202.1
Iron	0.50	0.18	EPA 236.1
Potassium	0.03	0.02	EPA 258.1
Magnesium	0.44	0.26	EPA 242.1
Silicon	0.76	0.18	SM 311 D
Carbon	4.23	4.97	ASTM E 1019
Sulfur	5.10	7.20	ASTM E 1019
Calcium	21.70	26.95	SM 2340 C
CaO Available	12.14	3.94	ASTM C 25
K ₂ O Available	0.04	0.02	EPA 258.1
Fe ₂ O ₃ Available	0.72	0.26	EPA 236.1
% Moisture	13.26	9.81	EPA 160.3
pH (units)	12.230	12.330	EPA 150.1

*all results in weight percent unless otherwise noted.

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

November 10 1998

To: Meeker Farms
Butch Meeker

Report #16171

Subject: Two bags of Bio - Cal for analysis.

<u>Element</u>	<u>Nod Dust</u>	<u>1 Kiln</u>	<u>Methods</u>
Aluminum	0.76	0.80	EPA 202.1
Iron	0.60	0.57	EPA 236.1
Potassium	0.51	0.52	EPA 258.1
Magnesium	0.86	0.73	EPA 242.1
Silicon	1.88	2.06	SM 311 D
Carbon	4.55	5.45	ASTM E 1019
Sulfur	3.25	3.65	ASTM E 1019
Calcium	34.00	39.50	SM 2340 C
CaO Available	6.00	9.18	ASTM C 25
K ₂ O Available	0.61	0.62	
Fe ₂ O ₃ Available	0.86	0.82	
% Moisture	12.14	0.09	EPA 160.3
pH (units)	12.024	12.171	EPA 150.1

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

October 22, 1998

To: Meeker Farms
Butch Meeker

Report #16133

Subject: One bag of Bio - Cal for analysis.

<u>Element</u>	<u>% by Wt.</u>	<u>Methods</u>
Aluminum	0.44	EPA 202.1
Iron	0.51	EPA 236.1
Potassium	0.05	EPA 258.1
Magnesium	0.85	EPA 242.1
Silicon	0.74	SM 311 D
Carbon	3.33	ASTM E 1019
Sulfur	5.64	ASTM E 1019
Calcium	36.05	SM 2340 C
CaO Available	18.74	ASTM C 25
K ₂ O Available	0.06	
Fe ₂ O ₃ Available	0.73	
% Moisture	17.03	EPA 160.3
pH (units)	11.374	EPA 150.1

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

March 25, 1998

To: Meeker Farms
Butch Meeker

Report #15543

Subject: One bag of Bio - Cal (5/20/98) for analysis.

Element % by Wt.

Aluminum	0.38
Iron	0.46
Potassium	0.05
Magnesium	0.72
Silicon	0.77
Carbon	3.20
Sulfur	4.45
Calcium	63.10
CaO Available	14.62
K ₂ O Available	0.06
Fe ₂ O ₃ Available	0.66

% Moisture	15.44
pH (units)	12.375

< = less than

Test Methods: ASTM E 1019

John O. Bloodsworth, P.E.

Douglas Darland/Chemist

Q.C. METALLURGICAL LABORATORY, INC.

Mechanical Testing • Metallographers • Chemical Analysis • Consultants

17048 215th Street, Davenport, Iowa 52804

(319) 386-7827 or (319) 386-8739 • FAX (319) 386-6780

March 12, 1998

To: Midwestern Bio-Ag
Dr. Bill Zimmer

File under Meeker germs.

Report #15481

Subject: One jar of Royster Clark - Calcium Hydroxide for analysis.

<u>Element</u>	<u>% by wt.</u>
Aluminum	0.34
Iron	0.50
Potassium	0.40
Magnesium	1.49
Silicon	0.77
Carbon	7.95
Sulfur	3.52
Calcium	64.10
CaO Available	5.60
K ₂ O Available	0.48
Fe ₂ O ₃ Available	0.71

(all above data given in % by wt.)

% Moisture 3.59
pH (units) 12.013

< = less than

*For od
mailed copy of
Report to Bill
Meeker*

FILE

John O. Bloodsworth
John O. Bloodsworth, P.E.

Douglas Darland/Chemist

3/17/98

April 04, 1997

To: Meeker Farms
Butch Meeker

Report #14401

Subject: Two samples for analysis.

	Bio-Cal 3-24	Bio-Cal 3-25
Aluminum	0.60	0.51
Iron	0.66	0.70
Potassium	0.15	0.21
Magnesium	0.50	0.43
Silicon	4.30	5.12
Carbon	4.85	5.07
Sulfur	4.99	5.35
Calcium (EDTA Titration)	37.05	40.65
CaO Available (Sugar Method)	13.84	13.77
K ₂ O Available	0.08	0.10
Fe ₂ O ₃ Available	0.73	0.81
% Moisture	9.21	12.31
pH	12.77 units	12.78 units

Sample for heavy metals

<u>Element</u>	<u>% by weight</u>
Arsenic	<0.01
Barium	57.69
Cadmium	<0.01
Chromium	<0.01
Lead	<0.01
Mercury	<0.01
Selenium	<0.01
Silver	<0.01

John O. Bloodsworth, P.E.

Douglas Darland/Analyst

January 6, 1998

To: Meeker Farms
Butch Meeker

Report #15279

Subject: One sample each of Bio-Cal, Kiln Dust, Hydrator Tailings,
and Waste for analysis.

<u>Parameter</u>	<u>Bio-Cal</u>	<u>Kiln Dust</u>	<u>Hyd. Tailings</u>	<u>Waste</u>
Aluminum	0.44	1.74	1.56	1.04
Iron	0.46	0.43	0.61	0.39
Potassium	0.07	0.61	0.14	0.05
Magnesium	0.78	0.97	0.98	1.17
Silicon	0.69	2.00	1.49	1.57
Carbon	5.9	5.7	3.3	2.60
Sulfur	6.6	2.0	0.58	0.50
Calcium	41.60	54.95	48.45	64.00
CaO Available	11.05	9.28	36.63	28.56
K ₂ O Available	0.08	0.73	0.17	0.06
Fe ₂ O ₃ Available	0.66	0.61	0.87	0.56

(all above data given in % by wt.)

% Moisture	14.32	<0.01	<0.01	<0.01
pH (units)	11.987	11.920	11.792	11.701

< = less than

John O. Bloodsworth, P.E.

Douglas Darland/Analyst

May 19, 1997

To: Meeker Farms
Butch Meeker

Report #14569

Subject: One sample for analysis.

	Bio-Cal
	5-12
	<u>Wt. %</u>
Aluminum	0.67
Iron	0.63
Potassium	0.13
Magnesium	0.89
Silicon	3.49
Carbon	6.2
Sulfur	3.9
Calcium (EDTA Titration)	41.49
CaO Available (Sugar Method)	14.25
K ₂ O Available	0.15
Fe ₂ O ₃ Available	0.90
% Moisture	9.30
pH	12.37 units

John O. Bloodsworth, P.E.

Douglas Darland/Analyst

95th

February 28, 1997

To: Meeker Farms
Butch Meeker

FAX	DATE 3/3	PAGES 1	FROM Linda
TO Butch	CO. Q. C. METALLURGICAL LABORATORY INC.		PH# 319-386-7827
CO.	FAX# 319-386-6780		

MESSAGE

Report #14307

Subject: Three samples for analysis.

	Bio-Cal 02-26 % by weight	Bottom Ash 02-26 % by weight	Bio-Cal 02-27 % by weight
Aluminum	0.37	0.47	0.47
Iron	1.26	0.88	1.20
Potassium	0.06	0.09	0.07
Magnesium	1.32	1.94	1.33
Silicon	4.17	10.12	9.37
Carbon	4.10	1.75	4.31
Sulfur	3.05	7.30	3.40
Calcium (EDTA Titration)	27.49	30.58	27.54
CaO Available (Sugar Method)	28.01	24.76	11.15
K ₂ O Available	0.08	0.10	0.08
Fe ₂ O ₃ Available	1.80	1.26	1.72
% Moisture	18.46	6.45	19.11
pH	12.17 units	11.90 units	12.36 units

John O. Bloodsworth, P.E.

Linda Peterson/Analyst



NATIONAL ENVIRONMENTAL TESTING, INC.

Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

11/06/1997

NET Job Number: 97.13319

NET Sample Number: 422124

Project ID: Total Composition Analysis

Sample ID: Bio Cal 10-97

Date Taken:

Date Received: 10/15/1997

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Result</u> <u>Flag</u>	<u>Analyst</u>	<u>Date</u> <u>Analyzed</u>	<u>Method</u>	<u>Reporting</u> <u>Limit</u>
Solid pH Measured in Water	12.2	units		mas	10/16/1997	S-9045	0.1
Phosphorus, Total (as P)	90	mg/kg	Wet	ajp	10/27/1997	E-365.2	50
Solids, Total	86.29	%		cjh	10/17/1997	SM 2540 G	0.01
Sulfur, Total	0.78	%		ajp	10/18/1997	ASTM D129-64	
Mercury, CVAA	<0.020	mg/kg		ajp	10/18/1997	E-245.5	0.020
Silicon	9,100	mg/kg		clw	10/29/1997	SM-3111	100
ICP Metals Prep (Solid)	Complete	g		maw	10/16/1997		
ICP Metals-Solid	.			llw	11/04/1997	S-6010B	
Aluminum, ICP	7,000	mg/kg	MSO,*	llw	10/20/1997	S-6010B	5.0
Antimony, ICP	<5.0	mg/kg	MSO	llw	10/22/1997	S-6010B	5.0
Arsenic, ICP	18	mg/kg		llw	10/20/1997	S-6010B	4.0
Barium, ICP	86	mg/kg		llw	10/20/1997	S-6010B	0.50
Beryllium, ICP	1.0	mg/kg		llw	10/20/1997	S-6010B	0.50
Boron, ICP	290	mg/kg		clw	10/29/1997	S-6010B	
Calcium, ICP	280,000	mg/kg	MSO,*	llw	10/22/1997	S-6010B	50
Cadmium, ICP	<1.0	mg/kg		llw	10/20/1997	S-6010B	1.0
Chromium, ICP	13	mg/kg		llw	10/20/1997	S-6010B	1.0
Cobalt, ICP	3.5	mg/kg		llw	10/20/1997	S-6010B	1.0
Copper, ICP	4.9	mg/kg		llw	10/20/1997	S-6010B	1.0
Iron, ICP	6,400	mg/kg	MSO,*	llw	10/20/1997	S-6010B	5.0
Lead, ICP	<5.0	mg/kg		llw	10/20/1997	S-6010B	5.0
Magnesium, ICP	6,500	mg/kg	MSO,*	llw	10/20/1997	S-6010B	50

* - Sample concentration is greater than four times the spike concentration

MSO - MS and/or MSD are out of control for this analyte

Results are reported on a wet weight basis.

R.L. Bindert
Operations Manager



NATIONAL ENVIRONMENTAL TESTING, INC.

Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

11/06/1997

NET Job Number: 97.13319

NET Sample Number: 422124

Project ID: Total Composition Analysis

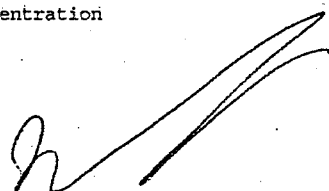
Sample ID: Bio Cal 10-97

Date Taken:

Date Received: 10/15/1997

Analyte	Result	Units	Result		Date		Reporting
			Flag	Analyst	Analyzed	Method	Limit
Manganese, ICP	890	mg/kg	MSO,*	llw	10/20/1997	S-6010B	0.50
Molybdenum, ICP	8.4	mg/kg		llw	10/20/1997	S-6010B	2.5
Nickel, ICP	14	mg/kg		llw	10/20/1997	S-6010B	2.5
Potassium, ICP	500	mg/kg		llw	10/20/1997	S-6010B	50
Selenium, ICP	<7.5	mg/kg		llw	10/20/1997	S-6010B	7.5
Sodium, ICP	320	mg/kg		llw	10/20/1997	S-6010B	50
Strontium, ICP	170	mg/kg		llw	10/20/1997	S-6010B	5.0
Thallium, ICP	<50	mg/kg		llw	10/20/1997	S-6010B	50
Vanadium, ICP	26	mg/kg		llw	10/20/1997	S-6010B	2.5
Zinc, ICP	59	mg/kg		llw	10/20/1997	S-6010B	1.0
Prep, BNA - NONAQUEOUS	complete			sdv	10/16/1997	S-3540	
BNA - 8270 NONAQUEOUS							COMPLETE
Acenaphthene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Acenaphthylene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Anthracene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Benzo(a)anthracene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Benzo(b)fluoranthene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Benzo(k)fluoranthene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Benzo(a)pyrene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Benzo(ghi)perylene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Chrysene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Dibenzo(a,h)anthracene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0

* - Sample concentration is greater than four times the spike concentration
MSO - MS and/or MSD are out of control for this analyte


R.L. Bindert
Operations Manager



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Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

11/06/1997

NET Job Number: 97.13319

NET Sample Number: 422124

Project ID: Total Composition Analysis

Sample ID: Bio Cal 10-97

Date Taken:

Date Received: 10/15/1997

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Result</u>		<u>Date</u>	<u>Method</u>	<u>Reporting</u>
			<u>Flag</u>	<u>Analyst</u>			
Fluoranthene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Fluorene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Indeno(1,2,3-cd)pyrene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
2-Methylnaphthalene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Naphthalene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Phenanthrene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Pyrene	<1.0	ug/g		kjt	10/21/1997	S-8270B	1.0
Calcium Carbonate Equivalent	730,000	mg/kg		kmv	11/06/1997	Calculation	

R.L. Bindert
Operations Manager



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Cedar Falls Division
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Cedar Falls, IA 50613
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Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

12/04/1997

NET Job Number: 97.14600

NET Sample Number: 426488

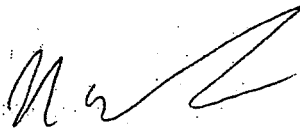
Project ID: Recheck/Bio Cal 10-97

Sample ID: Bio Cal 10-97

Date Taken:

Date Received: 11/13/1997

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Result</u> <u>Flag</u>	<u>Analyst</u>	<u>Date</u> <u>Analyzed</u>	<u>Method</u>	<u>Reporting</u> <u>Limit</u>
Sulfur, Total	0.72	%		lmc	12/01/1997	ASTM D129-64	
SPLP - Mercury	<0.0020	mg/L		ajp	12/03/1997	S-7470	0.0020
ICP SPLP METALS							
SPLP Arsenic (ICP)	<0.080	mg/L		llw	12/02/1997	S-6010B	0.080
SPLP Barium (ICP)	0.144	mg/L		llw	12/02/1997	S-6010B	0.100
SPLP Cadmium (ICP)	<0.020	mg/L		llw	12/02/1997	S-6010B	0.020
SPLP Chromium (ICP)	<0.020	mg/L		llw	12/02/1997	S-6010B	0.020
SPLP Lead (ICP)	<0.10	mg/L		llw	12/02/1997	S-6010B	0.10
SPLP Selenium (ICP)	<0.15	mg/L		llw	12/02/1997	S-6010B	0.15
SPLP Silver (ICP)	<0.020	mg/L		llw	12/02/1997	S-6010B	0.020


R.L. Bindert
Operations Manager



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704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

AMENDED REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437745

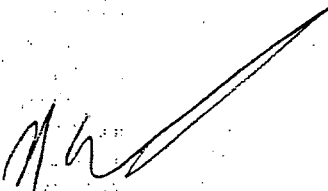
NET Job No: 98.01528

Sample ID: Sample #1 Bed Ash

Date Taken: Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Solid pH Measured in Water	11.3	units	02/12/1998	tkb	S-9045	0.1
Phosphorus, Total (as P)	65	mg/kg	02/19/1998	ajp	E-365.2	50
Solids, Total	99.91	%	02/16/1998	mcs	SM 2540 G	0.01
Sulfur, Total	1.6	%	02/24/1998	ajp	ASTM D129-64	
Mercury, CVAA	<0.020	mg/kg	02/18/1998	ajp	E-245.5	0.020
Silicon	2,900	mg/kg	02/19/1998	llw	SM-3111	100
ICP Metals Prep (Solid)	Complete	g	02/13/1998	maw		
ICP Metals-Solid	Complete		02/27/1998	kmv	S-6010B	
Aluminum, ICP	14,000	mg/kg	02/18/1998	llw	S-6010B	5.0
** Antimony, ICP	<5.0	mg/kg	02/18/1998	llw	S-6010B	5.0
Arsenic, ICP	39	mg/kg	02/18/1998	llw	S-6010B	4.0
Barium, ICP	250	mg/kg	02/18/1998	llw	S-6010B	0.50
** Beryllium, ICP	1.3	mg/kg	02/18/1998	llw	S-6010B	0.50
Boron, ICP	760	mg/kg	02/27/1998	kmv	S-6010B	
Calcium, ICP	240,000	mg/kg	02/18/1998	llw	S-6010B	50
** Cadmium, ICP	<1.1	mg/kg	02/18/1998	llw	S-6010B	1.0
Chromium, ICP	29	mg/kg	02/18/1998	llw	S-6010B	1.0
Cobalt, ICP	6.1	mg/kg	02/18/1998	llw	S-6010B	1.0
Copper, ICP	5.4	mg/kg	02/18/1998	llw	S-6010B	1.0
Iron, ICP	14,000	mg/kg	02/18/1998	llw	S-6010B	5.0
** Lead, ICP	<5.0	mg/kg	02/18/1998	llw	S-6010B	5.0
Magnesium, ICP	15,000	mg/kg	02/18/1998	llw	S-6010B	50
Manganese, ICP	850	mg/kg	02/18/1998	llw	S-6010B	0.50
Molybdenum, ICP	18	mg/kg	02/18/1998	llw	S-6010B	2.5

** Samples reported to MDL


R.L. Bindert
Operations Manager



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Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437745

NET Job No: 98.01528

Sample ID: Sample #1 Bed Ash

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Nickel, ICP	29	mg/kg	02/18/1998	llw	S-6010B	2.5
Potassium, ICP	800	mg/kg	02/18/1998	llw	S-6010B	50
** Selenium, ICP	<7.5	mg/kg	02/18/1998	llw	S-6010B	7.5
Sodium, ICP	400	mg/kg	02/18/1998	llw	S-6010B	50
Strontium, ICP	180	mg/kg	02/18/1998	llw	S-6010B	15
** Thallium, ICP	<50	mg/kg	02/18/1998	llw	S-6010B	50
Vanadium, ICP	58	mg/kg	02/18/1998	llw	S-6010B	2.5
Zinc, ICP	72	mg/kg	02/18/1998	llw	S-6010B	1.0
Prep, BNA - NONAQUEOUS	COMPLETE		02/12/1998	kyd	S-3540	
BNA - 8270 NONAQUEOUS						COMPLETE
Acenaphthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Acenaphthylene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Anthracene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo (a) anthracene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo (b) fluoranthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo (k) fluoranthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo (a) pyrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo (ghi) perylene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Chrysene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Dibenzo (a, h) anthracene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Fluoranthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Fluorene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Indeno (1, 2, 3-cd) pyrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
2-Methylnaphthalene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0

** Samples reported to MDL

R.L. Bindert
Operations Manager



NATIONAL
ENVIRONMENTAL
TESTING, INC.

Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437745

NET Job No: 98.01528

Sample ID: Sample #1 Bed Ash

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Naphthalene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Phenanthrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Pyrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Calcium carbonate equivalent	600,000	mg/kg	02/27/1998	kinv		

R.L. Bindert
Operations Manager

ANALYTICAL REPORT

Bill Zimmer
 MIDWESTERN BIO-AG, INC.
 P.O. Box 160
 Blue Mounds, WI 53517

04/07/1998

NET Job Number: 98.02512

NET Sample Number: 440909

Project ID: Dioxin & PCB Bed Ash/LKD

Sample ID: Sample #1 Bed Ash

Date Taken:

Date Received: 03/10/1998

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Result</u>		<u>Date Analyzed</u>	<u>Method</u>	<u>Reporting Limit</u>
			<u>Flag</u>	<u>Analyst</u>			
% Solids	100	%		cjh	03/10/1998		
Prep. PEST/PCB'S NONAQUEOUS	complete			djl	03/06/1998	S-3540	
DIOXIN Equivalent	<5.0	ppt		r'lb	03/28/1998	S-8290	
PESTICIDES/PCB'S Non-Aqueous							COMPLE
PCB-1016/1242	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1221	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1232	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1248	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1254	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1260	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1268	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5

Method 8290 performed by Triangle Laboratories.

R.L. Bindert
 Operations Manager



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Cedar Falls Division
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Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437746

NET Job No: 98.01528


Sample ID: Sample #4 LKD

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Solid pH Measured in Water	12.0	units	02/12/1998	tkb	S-9045	0.1
Phosphorus; Total (as P)	92	mg/kg	02/19/1998	ajp	E-365.2	50
Solids, Total	97.57	%	02/16/1998	mcs	SM 2540 G	0.01
Sulfur, Total	0.64	%	02/24/1998	ajp	ASTM D129-64	
Mercury, CVAA	<0.020	mg/kg	02/18/1998	ajp	E-245.5	0.020
Silicon	490	mg/kg	02/19/1998	llw	SM-3111	100
ICP Metals Prep (Solid)	Complete	g	02/13/1998	maw		
ICP Metals-Solid	Complete		02/27/1998	kmv	S-6010B	
Aluminum, ICP	5,200	mg/kg	02/18/1998	llw	S-6010B	5.0
** Antimony, ICP	8.4	mg/kg	02/18/1998	llw	S-6010B	5.0
** Arsenic, ICP	10	mg/kg	02/18/1998	llw	S-6010B	4.0
Barium, ICP	41	mg/kg	02/18/1998	llw	S-6010B	0.50
** Beryllium, ICP	0.66	mg/kg	02/18/1998	llw	S-6010B	0.50
Boron, ICP	35	mg/kg	02/27/1998	kmv	S-6010B	
Calcium, ICP	280,000	mg/kg	02/18/1998	llw	S-6010B	50
** Cadmium, ICP	<1.1	mg/kg	02/18/1998	llw	S-6010B	1.0
Chromium, ICP	7.7	mg/kg	02/18/1998	llw	S-6010B	1.0
Cobalt, ICP	3.5	mg/kg	02/18/1998	llw	S-6010B	1.0
Copper, ICP	11	mg/kg	02/18/1998	llw	S-6010B	1.0
Iron, ICP	6,300	mg/kg	02/18/1998	llw	S-6010B	5.0
** Lead, ICP	<5.0	mg/kg	02/18/1998	llw	S-6010B	5.0
Magnesium, ICP	23,000	mg/kg	02/18/1998	llw	S-6010B	50
Manganese, ICP	460	mg/kg	02/18/1998	llw	S-6010B	0.50
Molybdenum, ICP	13	mg/kg	02/18/1998	llw	S-6010B	2.5

** Samples reported to MDL


R.L. Bindert
Operations Manager



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ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437746

NET Job No: 98.01528


Sample ID: Sample #4 LKD

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Nickel, ICP	83	mg/kg	02/18/1998	llw	S-6010B	2.5
Potassium, ICP	1,400	mg/kg	02/18/1998	llw	S-6010B	50
** Selenium, ICP	<7.5	mg/kg	02/18/1998	llw	S-6010B	7.5
Sodium, ICP	380	mg/kg	02/18/1998	llw	S-6010B	50
Strontium, ICP	70	mg/kg	02/18/1998	llw	S-6010B	15
** Thallium, ICP	<50	mg/kg	02/18/1998	llw	S-6010B	50
Vanadium, ICP	240	mg/kg	02/18/1998	llw	S-6010B	2.5
Zinc, ICP	30	mg/kg	02/18/1998	llw	S-6010B	1.0
Prep: BNA - NONAQUEOUS	COMPLETE		02/12/1998	kyd	S-3540	
BNA - 8270 NONAQUEOUS						COMPLETE
Acenaphthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Acenaphthylene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Anthracene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo(a)anthracene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo(b)fluoranthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo(k)fluoranthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo(a)pyrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Benzo(ghi)perylene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Chrysene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Dibenzo(a,h)anthracene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Fluoranthene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Fluorene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Indeno(1,2,3-cd)pyrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
2-Methylnaphthalene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0

** Samples reported to MDL


R.L. Bindert
Operations Manager



NATIONAL
ENVIRONMENTAL
TESTING, INC.

Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437746

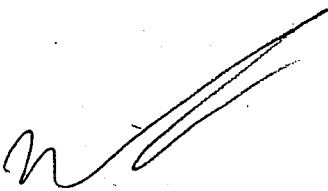
NET Job No: 98.01528

Sample ID: Sample #4 LKD

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Naphthalene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Phenanthrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Pyrene	<1.0	ug/g	02/13/1998	dmd	S-8270B	1.0
Calcium carbonate equivalent	700,000	mg/kg	02/27/1998	kmv		


R.L. Bindert
Operations Manager

ANALYTICAL REPORT

Bill Zimmer
 MIDWESTERN BIO-AG, INC.
 P.O. Box 160
 Blue Mounds, WI 53517

04/07/1998

NET Job Number: 98.02512

NET Sample Number: 440910

Project ID: Dioxin & PCB Bed Ash/LKD

Sample ID: Sample #4 LKD

Date Taken:

Date Received: 03/10/1998

<u>Analyte</u>	<u>Result</u>	<u>Units</u>	<u>Result</u>		<u>Date Analyzed</u>	<u>Method</u>	<u>Reporting Limit</u>
			<u>Flag</u>	<u>Analyst</u>			
% Solids	97.98	%		cjh	03/10/1998		
Prep. PEST/PCB'S NONAQUEOUS	complete			djl	03/06/1998	S-3540	
DIOXIN Equivalent	<5.0	ppt		r/b	03/28/1998	S-8290	
PESTICIDES/PCB'S Non-Aqueous							COMPLE
PCB-1816/1242	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1221	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1232	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1248	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1254	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1260	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5
PCB-1268	<0.5	ug/g		djl	03/07/1998	S-8080A	0.5

Method 8290 performed by Triangle Laboratories.

R.L. Bindert
 Operations Manager



NATIONAL ENVIRONMENTAL TESTING, INC.

Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437748

NET Job No: 98.01528

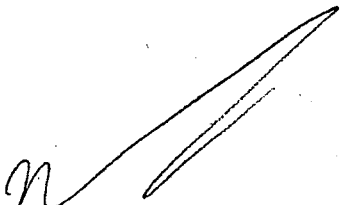
Sample ID: Sample #3 Ag Limestone

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Sulfur, Total	0.09	%	02/24/1998	ajp	ASTM D129-64	
Mercury, CVAA	<0.020	mg/kg	02/18/1998	ajp	E-245.5	0.020
ICP Metals Prep (Solid)	Complete	g	02/13/1998	maw		
ICP Metals-Solid	Complete	mg/kg	02/18/1998	llw	S-6010B	
** Arsenic, ICP	4.0	mg/kg	02/18/1998	llw	S-6010B	4.0
Calcium, ICP	240,000	mg/kg	02/18/1998	llw	S-6010B	50
** Cadmium, ICP	<1.0	mg/kg	02/18/1998	llw	S-6010B	1.0
Copper, ICP	3.6	mg/kg	02/18/1998	llw	S-6010B	1.0
** Lead, ICP	<5.0	mg/kg	02/18/1998	llw	S-6010B	5.0
Magnesium, ICP	1,700	mg/kg	02/18/1998	llw	S-6010B	50
Molybdenum, ICP	8.1	mg/kg	02/18/1998	llw	S-6010B	2.5
Nickel, ICP	9.3	mg/kg	02/18/1998	llw	S-6010B	2.5
** Selenium, ICP	<7.5	mg/kg	02/18/1998	llw	S-6010B	7.5
Zinc, ICP	23	mg/kg	02/18/1998	llw	S-6010B	1.0

** Samples reported to MDL


R.L. Bindert
Operations Manager



NATIONAL ENVIRONMENTAL TESTING, INC.

Cedar Falls Division
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Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437747

NET Job No: 98.01528


Sample ID: Sample #2 Gypsum

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Sulfur, Total	5.4	%	02/24/1998	ajp	ASTM D129-64	
Mercury, CVAA	<0.020	mg/kg	02/18/1998	ajp	E-245.5	0.020
ICP Metals Prep (Solid)	Complete	g	02/13/1998	maw		
ICP Metals-Solid	Complete	mg/kg	02/18/1998	llw	S-6010B	
** Arsenic, ICP	<4.0	mg/kg	02/18/1998	llw	S-6010B	4.0
Calcium, ICP	160,000	mg/kg	02/18/1998	llw	S-6010B	50
** Cadmium, ICP	<1.1	mg/kg	02/18/1998	llw	S-6010B	1.0
** Copper, ICP	<1.3	mg/kg	02/18/1998	llw	S-6010B	1.0
** Lead, ICP	<5.0	mg/kg	02/18/1998	llw	S-6010B	5.0
Magnesium, ICP	4,400	mg/kg	02/18/1998	llw	S-6010B	50
** Molybdenum, ICP	6.0	mg/kg	02/18/1998	llw	S-6010B	2.5
** Nickel, ICP	4.7	mg/kg	02/18/1998	llw	S-6010B	2.5
** Selenium, ICP	<7.5	mg/kg	02/18/1998	llw	S-6010B	7.5
Zinc, ICP	9.6	mg/kg	02/18/1998	llw	S-6010B	1.0

** Samples reported to MDL


R.L. Bindert
Operations Manager



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Cedar Falls Division
704 Enterprise Drive
Cedar Falls, IA 50613
Tel: (319) 277-2401
Fax: (319) 277-2425

ANALYTICAL REPORT

Bill Zimmer
MIDWESTERN BIO-AG, INC.
P.O. Box 160
Blue Mounds, WI 53517

02/27/1998

Sample No.: 437749

NET Job No: 98.01528

Sample ID: Sample #5 Calcium Oxide

Date Taken:

Date Received: 02/12/1998

	Result	Units	Date Analyzed	Analyst	Analysis Method	Reporting Limit
Sulfur, Total	0.10	%	02/24/1998	ajp	ASTM D129-64	
Mercury, CVAA	<0.020	mg/kg	02/18/1998	ajp	E-245.5	0.020
ICP Metals Prep (Solid)	Complete	g	02/13/1998	maw		
ICP Metals-Solid	Complete	mg/kg	02/18/1998	llw	S-6010B	
** Arsenic, ICP	7.5	mg/kg	02/18/1998	llw	S-6010B	4.0
Calcium, ICP	400,000	mg/kg	02/18/1998	llw	S-6010B	50
** Cadmium, ICP	<1.1	mg/kg	02/18/1998	llw	S-6010B	1.0
Copper, ICP	5.0	mg/kg	02/18/1998	llw	S-6010B	1.0
** Lead, ICP	<5.0	mg/kg	02/18/1998	llw	S-6010B	5.0
Magnesium, ICP	41,000	mg/kg	02/18/1998	llw	S-6010B	50
** Molybdenum, ICP	<2.5	mg/kg	02/18/1998	llw	S-6010B	2.5
Nickel, ICP	11	mg/kg	02/18/1998	llw	S-6010B	2.5
** Selenium, ICP	<7.5	mg/kg	02/18/1998	llw	S-6010B	7.5
Zinc, ICP	29	mg/kg	02/18/1998	llw	S-6010B	1.0

** Samples reported to MDL

R.L. Bindert
Operations Manager

Elena Babak

From: Beckman.Marguerite <beckman@niehs.nih.gov>
To: <ebabak@prestonengineering.com>
Cc: Mihok.Peter <mihok@niehs.nih.gov>
Sent: Monday, September 18, 2000 11:23 AM

Dear Ms. Babak,

Neither calcium hydroxide nor calcium oxide have been nominated or chosen for testing by the National Toxicology Program. The only references contained in our database on these two substances are in regard to other chemicals.

I did find 669 Material Safety Data Sheets containing calcium hydroxide at this Cornell University site:
<http://msds.pdc.cornell.edu/msdssrch.asp>

At the same site, a search on calcium oxide yielded 1617 MSDS documents.

These documents are prepared by the chemical manufacturers and detail safe-handling information for their products.

I hope this information is helpful.

Marguerite

NTP Central Data Management
919-541-3419 (VOICE)
919-541-3687 (FAX)
CDM@niehs.nih.gov
<http://ntp-server.niehs.nih.gov>

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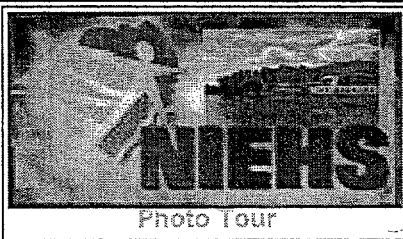


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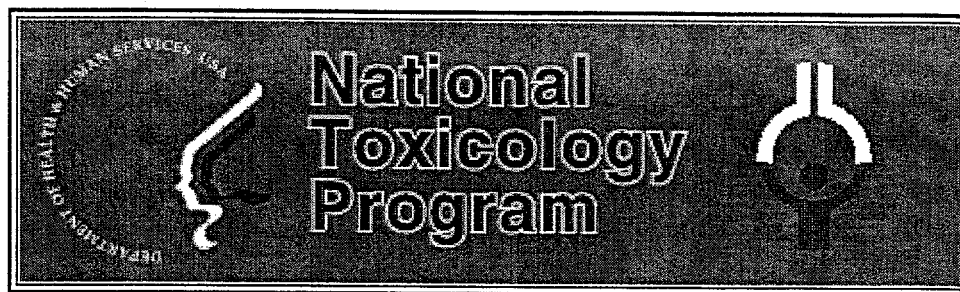
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What's New? (updated 9/15/00)

Meet the Director, NIEHS/NTP
Division of Intramural Research
(DIR)
Office of Scientific Director, DIR
Environmental Toxicology
Program, DIR

SEARCH the NTP study
databases

SUBSCRIBE to the NTP List
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How to NOMINATE a chemical

NTP Participating Agencies

NIEHS --- NIH

NCTR --- FDA

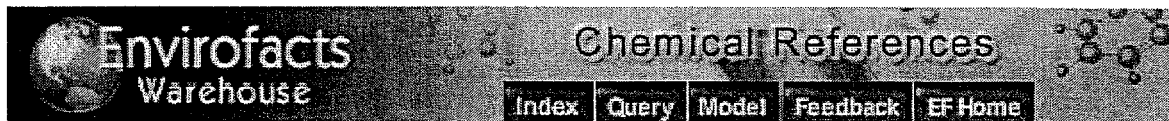
NIOSH --- CDC

- NTP Background
- NTP Factsheets
- Testing Information & Study Results
- NTP Report on Carcinogens
- Grants
- NTP Centers for the Evaluation of:
 - Alternative Toxicological Methods
 - Risks to Human Reproduction
 - NTP Center for Phototoxicology
- How Regulatory Agencies use NTP Data
- Announcements (Updated 9/15/2000)
- Meetings & Publications
- Chemical Health & Safety Information

NTP Reports Available Online at <http://ehis.niehs.nih.gov>

Updated 1/7/00

Contacts: About the NTP Server Mike Rowley; about the NTP Studies Dr. William Eastin.




Envirofacts Warehouse Chemical References

CALCIUM OXIDE CAS #1305-78-8


The following information resources are not maintained by Envirofacts. Envirofacts is neither responsible for their informational content nor for their site operation, but provides references to them here as a convenience to our Internet users.

Reference information on this chemical can be found at the following locations:

EPA Locations and Other Governmental Locations

- New Jersey's Department of Health, Right to Know Program's Hazardous Substance  **Fact Sheets** provide chemical information on acute and chronic health hazards, identification, workplace exposure limits, and risk reductions.

Non-Governmental Organizations

- The Environmental Defense Fund's  **Chemical Scorecard** summarizes information about health effects, hazard rankings, industrial and consumer product uses, environmental releases and transfers, risk assessment values and regulatory coverage.

These pages are maintained by the Envirofacts Support Team at the EPA Systems Development Center.
For comments, problems or suggestions, please use the [Envirofacts Feedback Form](#).

This page was updated July 23, 1998.

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **CALCIUM OXIDE**

CAS Number: 1305-78-8
DOT Number: UN 1910

RTK Substance number: 0325
Date: January 1986 Revision: September 1996

HAZARD SUMMARY

- * **Calcium Oxide** can affect you when breathed in.
- * Contact can severely irritate and burn the eyes and skin.
- * Breathing **Calcium Oxide** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.
- * Long-term exposure can irritate the nose, causing a hole in the "bone" dividing the inner nose, and can cause brittle nails and thickening and cracking of the skin.

IDENTIFICATION

Calcium Oxide (lime) is a white-to-gray, odorless solid. It is used in building materials, metal processing, agriculture and sewage treatment.

REASON FOR CITATION

- * **Calcium Oxide** is on the Hazardous Substance List because it is regulated by OSHA and cited by ACGIH, DOT and NIOSH.
- * Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

- * Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
- * If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

- OSHA: The legal airborne permissible exposure limit (PEL) is **5 mg/m³** averaged over an 8-hour workshift.
- NIOSH: The recommended airborne exposure limit is **2 mg/m³** averaged over a 10-hour workshift.
- ACGIH: The recommended airborne exposure limit is **2 mg/m³** averaged over an 8-hour workshift.

WAYS OF REDUCING EXPOSURE

- * Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
- * Wear protective work clothing.
- * Wash thoroughly immediately after exposure to **Calcium Oxide** and at the end of the workshift.
- * Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Calcium Oxide** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Calcium Oxide**:

- * Contact can severely irritate and burn the eyes and skin.
- * Breathing **Calcium Oxide** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Calcium Oxide** and can last for months or years:

Cancer Hazard

- * According to the information presently available to the New Jersey Department of Health and Senior Services, **Calcium Oxide** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard

- * According to the information presently available to the New Jersey Department of Health and Senior Services, **Calcium Oxide** has not been tested for its ability to affect reproduction.

Other Long-Term Effects

- * Long-term exposure can irritate the nose, causing a hole in the "bone" dividing the inner nose.
- * **Calcium Oxide** can cause brittle nails and thickening and cracking of the skin.
- * **Calcium Oxide** can irritate the lungs. Repeated exposures may cause bronchitis to develop with cough, phlegm, and/or shortness of breath.

MEDICAL

Medical Testing

For those with frequent or potentially high exposure (half the TLV or greater), the following are recommended before beginning work and at regular times after that:

- * Lung function tests.

If symptoms develop or overexposure is suspected, the following may be useful:

- * Consider chest x-ray after acute overexposure.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

Mixed Exposures

Because smoking can cause heart disease, as well as lung cancer, emphysema, and other respiratory problems, it may worsen respiratory conditions caused by chemical exposure. Even if you have smoked for a long time, stopping now will reduce your risk of developing health problems.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following control is recommended:

- * Where possible, automatically transfer **Calcium Oxide** from drums or other storage containers to process containers.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

- * Workers whose clothing has been contaminated by **Calcium Oxide** should change into clean clothing promptly.
- * Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **Calcium Oxide**.

- * Eye wash fountains should be provided in the immediate work area for emergency use.
- * If there is the possibility of skin exposure, emergency shower facilities should be provided.
- * On skin contact with **Calcium Oxide**, immediately wash or shower to remove the chemical.
- * Do not eat, smoke, or drink where **Calcium Oxide** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.
- * Use a vacuum or a wet method to reduce dust during clean-up. DO NOT DRY SWEEP.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

- * Avoid skin contact with **Calcium Oxide**. Wear protective gloves and clothing. Safety equipment suppliers/ manufacturers can provide recommendations on the most protective glove/clothing material for your operation.
- * All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Eye Protection

- * Wear dust-proof goggles and face shield when working with powders or dust, unless full facepiece respiratory protection is worn.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS.

Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

- * Where the potential exists for exposures over 2 mg/m^3 , use a MSHA/NIOSH approved full facepiece respirator with a high efficiency particulate filter. Greater protection is provided by a powered-air purifying respirator.

- * If while wearing a filter, cartridge or canister respirator, you can smell, taste, or otherwise detect **Calcium Oxide**, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Check to make sure the respirator-to-face seal is still good. If it is, replace the filter, cartridge, or canister. If the seal is no longer good, you may need a new respirator.
- * Be sure to consider all potential exposures in your workplace. You may need a combination of filters, prefilters, cartridges, or canisters to protect against different forms of a chemical (such as vapor and mist) or against a mixture of chemicals.
- * Where the potential for high exposures exists, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in the positive pressure mode or with a full facepiece, hood, or helmet in the continuous flow mode, or use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
- * Exposure to 25 mg/m^3 is immediately dangerous to life and health. If the possibility of exposure above 25 mg/m^3 exists, use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in continuous flow or other positive pressure mode.

HANDLING AND STORAGE

- * Prior to working with **Calcium Oxide** you should be trained on its proper handling and storage.
- * **Calcium Oxide** must be stored to avoid contact with CHLORINE TRIFLUORIDE and LIQUID HYDROFLUORIC ACID, since violent reactions occur. OXIDIZERS (such as PEROXIDES, CHLORATES, PERCHLORATES, NITRATES and PERMANGANATES).
- * Store in tightly closed containers in a cool, well-ventilated area away from WATER or MOISTURE. **Calcium Oxide** swells when moist and may burst storage containers.

QUESTIONS AND ANSWERS

- Q: If I have acute health effects, will I later get chronic health effects?
- A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?

A: Conditions which increase risk of exposure include dust releasing operations (grinding, mixing, blasting, dumping, etc.), other physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?

A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.

The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information

Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation

If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations

Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources

The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m³ means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

CALCIUM OXIDE

CASRN: 1305-78-8

*For other data, click on the Table of Contents***Human Health Effects:****Human Toxicity Excerpts:**

INDUSTRIAL EXPERIENCE HAS SHOWN IT TO BE VERY IRRITANT TO...MUCOUS MEMBRANES & MOIST SKIN AS RESULT OF LOCAL LIBERATION OF HEAT & DEHYDRATION OF TISSUES UPON SLAKING OF SMALL SIZE PARTICLES & THE RESULTING ALKALINITY OF SLAKED PRODUCT. INFLAMMATION OF RESPIRATORY PASSAGES...ULCERATION & PERFORATION OF NASAL SEPTUM, &...PNEUMONIA HAVE BEEN ATTRIBUTED TO INHALATION OF LIME DUST. MAJOR COMPLAINTS OF WORKERS EXPOSED TO LIME CONSISTS OF IRRITATION OF SKIN & EYES...

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values, 4th ed., 1980. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, Inc., 1980. 63]**QC REVIEWED**

SEE LYE. SYMPTOMATOLOGY: 1. INGESTION OF LYE CAUSES SWALLOWING TO BECOME PAINFUL & DIFFICULT ALMOST IMMEDIATELY. BURNING PAIN EXTENDS DOWN ESOPHAGUS TO STOMACH. CONTAMINATED AREAS OF LIPS, CHIN, TONGUE & PHARYNX BECOME EDEMATOUS & COVERED WITH EXUDATE. PROFUSE SALIVATION. BECAUSE OF PHARYNGEAL AND ESOPHAGEAL EDEMA, IT MAY BECOME IMPOSSIBLE AFTER A FEW HOURS TO SWALLOW EVEN SALIVA. MUCOUS MEMBRANES ARE AT FIRST WHITE BUT LATER BROWN, EDEMATOUS, GELATINOUS, AND NECROTIC. 2. VOMITUS IS THICK AND SLIMY DUE TO MUCUS; LATER IT MAY CONTAIN BLOOD AND SHREDS OF MUCOUS MEMBRANE. /LYE/

[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-72]**QC REVIEWED**

SEE LYE. SYMPTOMATOLOGY /INGESTION/: 3. PULSE IS OFTEN RAPID & FEEBLE; RESPIRATIONS ARE FAST & SHALLOW; SKIN IS COLD & CLAMMY; COLLAPSE ENSUES. 4. DEATH DUE TO SHOCK, ASPHYXIA FROM GLOTTIC EDEMA OR INTERCURRENT INFECTION (PNEUMONIA) COMMONLY OCCURS ON 2ND OR...3RD DAY. ASPIRATION PNEUMONITIS HAS BEEN DESCRIBED. 5. CONVALESCENCE MAY BE INTERRUPTED DURING FIRST WEEK BY ESOPHAGEAL PERFORATION OR PERHAPS EVEN GASTRIC PERFORATION. MEDIASTITIS MAY PRESENT AS SEVERE SUBSTERNAL PAIN WITH FEVER. 6. IF COMPLICATIONS DO NOT APPEAR, LIQUID AND SOFT FOOD CAN BE SWALLOWED WITH COMPARATIVE EASE WITHIN 5 TO 7 DAYS. ...IN MOST CASES THIS ABSENCE OF DISTRESS MARKS LATENT PERIOD AND THAT ESOPHAGEAL STRICTURES WILL DEVELOP WITHIN WEEKS OR MONTHS UNLESS EFFECTIVE TREATMENT IS INSTITUTED. /LYE/

[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-72]**QC REVIEWED**

MAY PRODUCE...THERMAL...BURN.

[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-72]**QC REVIEWED**

IN ADDN TO GENERATION OF HEAT...LIME...ON REACHING EYE TENDS TO REACT WITH MOISTURE & PROTEIN...& FORM CLUMPS OF MOIST COMPD, VERY DIFFICULT

TO REMOVE BY USUAL IRRIGATION. SUCH CLUMPS TEND TO LODGE DEEP IN CUL-
DE-SACS INFERIORLY & SUPERIORLY & ACT AS RESERVOIRS FOR LIBERATION OF
CALCIUM HYDROXIDE OVER LONG PERIODS OF TIME.

[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's
Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 278]**QC REVIEWED**

Skin, Eye and Respiratory Irritations:

Dust is irritating to nose & throat. Solid will burn skin & eyes.

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data.
Manual Two. Washington, DC: U.S. Government Printing Office, Oct., 1978.]**QC
REVIEWED**

Probable Routes of Human Exposure:

During lime production, workers may be exposed to atmospheric dust, /&/ the prodn of hazardous
gases... Dust is hazard in...manual crushing, screening, drying, packaging & loading of lime itself, to
builders, plasterers, agricultural workers...using pure lime & in use & handling of materials of which
lime is a component such as basic slag, cement or calcium cyanamide.

[International Labour Office. Encyclopedia of Occupational Health and Safety.
Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1234]**QC
REVIEWED**

CALCIUM OXIDE

CASRN: 1305-78-8

*For other data, click on the Table of Contents***Substance Identification:****Substance Name:** CALCIUM OXIDE**CAS Registry Number:** 1305-78-8**Data Type:**

Mutagenicity

Studies Data:**Mutagenicity Studies:**

Test System: AMES SALMONELLA TYPHIMURIUM
Strain Indicator: TA100
Metabolic Activation: NONE
Method: PREINCUBATION
Dose: 0-1.2 G/L (TEST MATERIAL SOLVENT: PHOSPHATE BUFFER)
Results: NEGATIVE
Reference:

[SAWAI, J, SAITO, I, KANOU, F, IGARASHI, H, HASHIMOTO, A, KOKUGAN, T AND SHIMIZU, M;
MUTAGENICITY TEST OF CERAMIC POWDERS WHICH HAVE GROWTH INHIBITORY EFFECT ON
BACTERIA; J. CHEM. ENG. JPN. 28(3):352-354, 1995]

Test System: AMES SALMONELLA TYPHIMURIUM
Strain Indicator: TA100
Metabolic Activation: RAT, LIVER, S-9
Method: PREINCUBATION
Dose: 0-1.2 G/L (TEST MATERIAL SOLVENT: PHOSPHATE BUFFER)
Results: NEGATIVE
Reference:

[SAWAI, J, SAITO, I, KANOU, F, IGARASHI, H, HASHIMOTO, A, KOKUGAN, T AND SHIMIZU, M;
MUTAGENICITY TEST OF CERAMIC POWDERS WHICH HAVE GROWTH INHIBITORY EFFECT ON
BACTERIA; J. CHEM. ENG. JPN. 28(3):352-354, 1995]

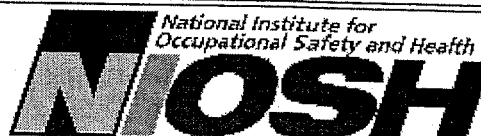
Administrative Information:**CCRIS Record Number:** 7496**Last Revision Date:** 19970801**Update History:**

Complete Update on 08/01/1997, 4 fields added/edited/deleted.

International Chemical Safety Cards

CALCIUM OXIDE

ICSC: 0409



CALCIUM OXIDE

Lime

Burnt lime

Quicklime

CaO

Molecular mass: 56.1

CAS # 1305-78-8

RTECS # EW3100000

ICSC # 0409

UN # 1910



TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
FIRE	Not combustible.		In case of fire in the surroundings: all extinguishing agents allowed except water.
EXPLOSION			
EXPOSURE		PREVENT DISPERSION OF DUST! STRICT HYGIENE!	
• INHALATION	Burning sensation. Cough. Shortness of breath. Sore throat.	Local exhaust or breathing protection.	Fresh air, rest. Refer for medical attention.
• SKIN	Dry skin. Redness. Skin burns. Burning sensation. Pain.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention.
• EYES	Redness. Pain. Blurred vision. Severe deep burns.	Safety goggles, or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
• INGESTION	Burning sensation. Abdominal pain. Abdominal cramps. Vomiting. Diarrhoea.	Do not eat, drink, or smoke during work.	Rinse mouth. Do NOT induce vomiting. Give nothing to drink. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Sweep spilled substance into dry containers (extra personal protection: P2 filter respirator for harmful particles).	Separated from strong acids, organics, water, food and feedstuffs. Dry.	Do not transport with food and feedstuffs. UN Hazard Class: 8 UN Packing Group: III

SEE IMPORTANT INFORMATION ON BACK


ICSC: 0409

Prepared in the context of cooperation between the International Programme on Chemical Safety & the Commission of the European Communities © IPCS CEC 1993 No modifications to the International version have been made except to add the OSHA PELs, NIOSH RELs and IDLH values.

International Chemical Safety Cards

CALCIUM OXIDE

ICSC: 0409

I M P O R T A N T D A T A	<p>PHYSICAL STATE; APPEARANCE: HYGROSCOPIC, WHITE CRYSTALLINE POWDER.</p> <p>PHYSICAL DANGERS:</p> <p>CHEMICAL DANGERS: The solution in water is a medium strong base. Reacts with water generating sufficient heat to ignite combustible materials. Reacts violently with acids, halogens, metals.</p> <p>OCCUPATIONAL EXPOSURE LIMITS (OELs): TLV: 2 ppm; mg/m³ (ACGIH 1996). MAK: 5 ppm; mg/m³; (1996). OSHA PEL: TWA 5 mg/m³ NIOSH REL: TWA 2 mg/m³ NIOSH IDLH: 25 mg/m³</p>	<p>ROUTES OF EXPOSURE: The substance can be absorbed into the body by inhalation of its aerosol and by ingestion.</p> <p>INHALATION RISK: Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed.</p> <p>EFFECTS OF SHORT-TERM EXPOSURE: The substance is corrosive to the eyes, the skin and the respiratory tract. The effects may be delayed. Medical observation is indicated.</p> <p>EFFECTS OF LONG-TERM OR REPEATED EXPOSURE: Repeated or prolonged contact with skin may cause dermatitis. Lungs may be affected by repeated or prolonged exposure to dust particles. The substance may cause ulceration and perforation of the nasal septum.</p>
PHYSICAL PROPERTIES	Boiling point: 2850°C Melting point: 2570°C	Relative density (water = 1): 3.3-3.4 Solubility in water: reaction
ENVIRONMENTAL DATA		
NOTES		
<p>Reacts violently with fire extinguishing agents such as water. Clumps of calcium oxide formed by reaction with moisture and proteins in the eye are difficult to remove by irrigation. Manual removal by a physician is necessary. NEVER pour water into this substance; when dissolving or diluting always add it slowly to the water.</p> <p style="text-align: right;">Transport Emergency Card: TEC (R)-67</p>		
ADDITIONAL INFORMATION		
ICSC: 0409		CALCIUM OXIDE
© IPCS, CEC, 1993		
IMPORTANT LEGAL NOTICE:	<p>Neither NIOSH, the CEC or the IPCS nor any person acting on behalf of NIOSH, the CEC or the IPCS is responsible for the use which might be made of this information. This card contains the collective views of the IPCS Peer Review Committee and may not reflect in all cases all the detailed requirements included in national legislation on the subject. The user should verify compliance of the cards with the relevant legislation in the country of use. The only modifications made to produce the U.S. version is inclusion of the OSHA PELs, NIOSH RELs and IDLH values.</p>	

NIOSH Pocket Guide to Chemical Hazards

Calcium oxide		CAS 1305-78-8	
CaO		RTECS EW3100000	
Synonyms & Trade Names Burned lime, Burnt lime, Lime, Pebble lime, Quick lime, Unslaked lime		DOT ID & Guide 1910 157	
Exposure Limits	NIOSH REL: TWA 2 mg/m ³		
	OSHA PEL: TWA 5 mg/m ³		
IDLH 25 mg/m ³ See: 1305788		Conversion	
Physical Description White or gray, odorless lumps or granular powder.			
MW: 56.1	BP: 5162°F	MLT: 4662°F	Sol: Reacts
VP: 0 mmHg (approx)	IP: NA		Sp.Gr: 3.34
F.L.P: NA	UEL: NA	LEL: NA	
Noncombustible Solid, but will support combustion by liberation of oxygen.			
Incompatibilities & Reactivities Water (liberates heat), fluorine, ethanol [Note: Reacts with water to form calcium hydroxide.]			
Measurement Method Filter; Acid; Flame atomic absorption spectrometry; IV [#7020, Calcium] See: NMAM INDEX			
Personal Protection & Sanitation Skin: Prevent skin contact Eyes: Prevent eye contact Wash skin: When contaminated/Daily Remove: When wet or contaminated Change: Daily Provide: Eyewash, Quick drench		First Aid (See procedures) Eye: Irrigate immediately Skin: Water flush immediately Breathing: Respiratory support Swallow: Medical attention immediately	
Respirator Recommendations NIOSH Up to 10 mg/m ³ : (APF = 5) Any dust and mist respirator Up to 20 mg/m ³ : (APF = 10) Any dust and mist respirator except single-use and quarter-mask respirators/(APF = 10) Any supplied-air respirator Up to 25 mg/m ³ : (APF = 25) Any supplied-air respirator operated in a continuous-flow mode/ (APF = 25) Any powered, air-purifying respirator with a high-efficiency particulate filter/(APF = 50) Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter/(APF = 50) Any self-contained breathing apparatus with a full facepiece/(APF = 50) Any supplied-air respirator with a full facepiece Emergency or planned entry into unknown concentrations or IDLH conditions: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode/(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus Escape: (APF = 50) Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter/Any appropriate escape-type, self-contained breathing apparatus			
Exposure Routes inhalation, ingestion, skin and/or eye contact			

Symptoms irritation eyes, skin, upper respiratory tract; ulcer, perforation nasal septum; pneumonia; dermatitis

Target Organs Eyes, skin, respiratory system

See also: INTRODUCTION See ICSC CARD: 0409



Calcium monoxide

- **Formula:** CaO
- **Molecular Weight:** 56.08
- **CAS Registry Number:** 1305-78-8
- **Chemical Structure:**



This structure is also available as a 2d Mol file.

- **Other Names:** Calcium oxide; Lime; CaO; Burnt lime; Calcia; Calx; Calcium oxide (CaO); Lime, burned; Lime, unslaked; Oxyde de calcium; Quicklime; UN 1910; Wapniowy tlenek
- **Notes / Error Report**
- **Other Data Available:**
 - Gas phase thermochemistry data
 - Condensed phase thermochemistry data
 - Gas phase ion energetics data
 - Constants of Diatomic Molecules
- Switch to calorie-based units

Notes / Error Report

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 TLV

 WHMI

NOSB Materials Database**Identification**

Common Name	Lime, Hydrated	Chemical Name	
Other Names	Dolomitic Hydrated Lime	Code #: Other	
Code #: CAS			
N. L. Category	Synthetic Allowed		

Chemistry

Composition	36% Ca and 20% Mg. CaOH	Family	
Properties	Soft White Crystalline Powder Odorless		
How Made	Hydrated lime is made by burning limestone gradually in a lime kiln and then adding the right amount of water.		

Use/Action

Type of Use	Crops
Use(s)	Only as a foliar for disease control, primarily as a component of Bordeaux mix.

Action**Combinations****Status****OFPA**

N. L. Restriction Only for use as a foliar. Prohibited for use as a fertilizer.

EPA, FDA, etc**Registration****Directions**

Safety Guidelines Respiratory Protection, Ventilation, Eye Protection

State Differences**Historical status**

Allowed as fungicide only by a wide majority of certification groups. In use for over 100 years.

International status

OCIA: Accepted; Allowed by European certifiers as a component of Bordeaux mix.

NOSB Materials Database

OFPA Criteria

2119(m)1:chem. inter. Hazardous Components: Calcium Hydroxide, Magnesium Hydroxide, Calcium Carbonate, Silicon Dioxide
 Incompatibility: Acids and Ammonium Salts, Some Organic Compounds

2119(m)2: toxicity Breaks down readily in the soil into Calcium carbonate (limestone) and water.

2119(m)3:manufacture

2119(m)4:humans
 -Use respiratory protection
 -Safety goggles while handling
 -Body covering protective clothing

2119(m)5: biology The trace amounts reaching the soil from foliar application would have the positive effect of contributing calcium. In direct soil application however, it would create a strong imbalance of soluble calcium which would negatively affect soil microbes and cause rapid oxidation of other soil nutrients.

2119(m)6:alternatives Copper alone, sulfur, hydrogen peroxide (in some situations)

2119(m)7:compatible

References

- Pure Gro: 1276 Halyard Dr. West Sacramento, CA 1-800-247-2133
- Helena Chemical Co: Clark Tower #3200 5100 Poplar Ave. Memphis, TN 901-761-0050
- Necessary Trading Co: P.O. Box 305 8312 Salem Ave. New Castle, VA .800-447-5354

4

SilverPlatter v 2.15

HYDRATED LIME REFERENCES

AGRICOLA (1992 - June 1994)

AU: Boucher,-J.; Adams,-R.

TI: Hydrated lime as an insect repellent.

SO: Grow-Veg-Small-Fruit-Newsl. Storrs, Conn. : Coop. Ext. Serv., USDA, College of Agriculture & Natural Resources, Univ. of Conn. Feb 1993. v. 93 (2) p. 4.

CN: DNAL SB321.G85

PY: 1993

AU: Metzger,-W.H.

TI: The rates of reaction with acid soils of finely divided soil liming materials.

SO: J-Am-Soc-Agron. Madison, Wis. : American Society of Agronomy. June 1933. v. 25 (6) p. 377-383.

CN: DNAL 4-AM34P

PY: 1933

AB: The study reported pertains to the reaction rates of four finely divided liming materials with two acid soils. The materials included were hydrated lime, pulverized high calcium limestone, pulverized dolomitic limestone, and a by-product precipitated calcium carbonate known commercially as "Plant Lime". All materials were employed at three rates of application and in chemically equivalent amounts. Change in pH, decrease in Jones lime requirement, and decrease in total carbonates were used as criteria of rate of reaction. The incubation periods varied from 1 week to 1 year. Both pH change and decrease in lime requirement proved unreliable indicators of rate of reaction. The former remained approximately constant after 1 week. Lime requirement reached a minimum in 1 or 2 weeks and thereafter showed a material increase. Based upon the disappearance of carbonates, hydrated lime and the precipitated carbonate were about equally rapid in reaction. The precipitated carbonate reacted faster than the high calcium limestone. The difference can probably be accounted for by the somewhat greater fineness of the former. The dolomitic limestone was measurably less active than the high calcium limestone, the difference largely disappearing after 2 months incubation. It is doubtful whether any practical significance may be attributed to the differences in rates of reaction among the materials studied.

AU: MacIntire,-W.H.; Sanders,-K.B.; Shaw,-W.M.

TI: The availability of hydrated lime, limestone, and dolomite of two degrees of fineness, with supplements of red clover hay, as measured by lysimeter leachings.

SO: J-Am-Soc-Agron. Madison, Wis. : American Society of Agronomy. Apr 1933. v. 25 (4) p. 285-297.

CN: DNAL 4-AM34P

PY: 1933

AB: In applying the foregoing results obtained in a 4-year study with 18 pairs of lysimeters several points are to be considered. Commercial limestone and the home-ground products differ. The former is often a product consisting solely of finely ground material. The latter is generally a mixture of different finenesses, limited by the character of rock as it affects tonnage per diem in grinding, wear on machinery, and ultimate cost. Since the commercial products are usually finer than the coarser separates used in the present experiment, the results may be interpreted as applying directly for such products and for types of soil similar to the one used and under comparable climatic conditions. For a soil of good fixing capacity, even without marked acidity, the 100- to 200-mesh fineness of either limestone or dolomite is comparable to an equivalence of hydrated lime, when evaluated by enhanced nitrification and sulfate generation, soluble Ca plus Mg, and repressive effects upon

potassium solubility for the 4-year period. The same holds for the 40- to 50-mesh limestone. The 40- to 50-mesh dolomite is not so readily available during the first year, but the disparity is not great. Since the heavier types of soils of greater acidity would effect a disintegration more rapid and intensive than that found for the well-buffered, near-neutral soil used, it would follow that the fineness of 40- to 50-mesh is ample for such soils, especially if an appreciable period elapse between the incorporation and the seeding. For sandy soils, however, it would be expected that the differences attributable to fineness would be greater than those found for the heavier type of soil. This would be especially true in case of the less soluble dolomite, which should be exceedingly fine when used in sandy soils. Although the total amounts of soluble Ca plus Mg derived from the several dolomite additions were generally comparable to, though slightly in excess of, those found for the corresponding limestone addition, there was a distinct difference in the proportions of the two elements present in the free-soil water. This is accounted for not only by marked enhancement of soluble magnesium derived from the dolomite, but also by the diminished outgo of native magnesium where the high-calcic materials were used. The red clover hay increased the outgo of calcium and magnesium, the largest changes being noted during the first year, but this increase was due, primarily, to the amount of soluble calcium and magnesium supplied by the red clover additions. Hence, the addition of green manure did not appreciably increase loss of the Ca plus Mg supplied by the liming materials. As a close approximation, applying to all forms, one-fourth of the added liming materials was lost during the 4-year period. The several materials may be considered of comparable value in their tendencies to increase supplies of nitrates and sulfates. When applied to home-ground limestone, the findings indicate that such a product may well be evaluated on the basis of the fraction that is of the fineness less than 40-mesh. The coarser fractions ultimately undergo disintegration, but for immediate use the evaluation should be on the fraction that would pass a 40-mesh sieve. As has been pointed out (3, 5), the factors of seasons and depth of incorporation are also to be considered.

AU: Walker, R.H.; Brown, P.E.

TI: Nitrification in the Grundy silt loam as influenced by liming.

SO: J-Am-Soc-Agron, Madison, Wis. : American Society of Agronomy. May 1935. v. 27

(5) p. 356-363.

CN: DNAL 4-AM34P

PY: 1935

AB: 1. Plots of Grundy silt loam were treated with different amounts of quarry-run limestone, with limestones of different degrees of fineness, and with hydrated lime. The soil of these plots was sampled frequently over a period of 5 years and its nitrifying power was determined. 2. The limestones and hydrated lime exerted an appreciable effect on the pH and also the nitrifying power of the soil. The changes in nitrifying power appeared to be associated directly with the changes in hydrogen-ion concentration, these changes being, to a certain extent, a function of the amount of limestone, or of the degree of fineness of the limestone applied. 3. The data were analyzed statistically to determine the significance of the differences in nitrifying power of the variously treated soils. This analysis shows that where limestone was applied in amounts less than the lime requirement of the soil or slightly above, the mean increases in nitrifying power induced by 1-ton additional applications of limestone were comparatively large and rather consistent, but they are not quite large enough to be significant. 4. Two-ton increases in amounts of limestone applied, induced such large increases in nitrifying power that they were significant or highly significant in each case. 5. Where limestone was applied in amounts beyond the lime requirement of the soil, the increase in nitrifying power induced per unit of limestone was reduced somewhat, and larger additional amounts were found necessary to bring about significant increases in nitrifying power. 6. The 5-year means of the nitrifying power of soils treated with equal amounts of quarry-run, 20-mesh, 40-mesh, and 100-mesh

limestones were comparatively uniform, and all except that for the 40-mesh limestone were significantly lower than that for the hydrated lime. The mean difference in nitrifying power between the 40-mesh and hydrated lime treated soils lacked only a very small amount of being significant statistically.

AU: Hartwell, -B.L.; Damon, -S.C.

TI: Relative lime needs of sulfate of ammonia and nitrate of soda and of different crops.

SO: J-Am-Soc-Agron. Madison, Wis. : American Society of Agronomy. Sept 1927. v. 19 (9) p. 843-849.

CN: DNAL 4-AM34P

PY: 1927

AB: This paper contains the results for 1915 to 1926 of a field comparison, conducted since 1893, of equal amounts of nitrogen in sulfate of ammonia and nitrate of soda accompanied by liberal amounts of phosphorus and potassium. Prior to 1915, each source of nitrogen had been accompanied by an equal amount of lime, and also had been used without lime. Subsequently, extra lime was applied to the more-limed sulfate plat to make its reaction like that of the limed nitrate plat. The average pounds of calcium oxid per year during the 34 years was 275 applied to the limed nitrate plat and 422 to the more-limed sulfate plat. The average annual application of nitrogen was 49 pounds, therefore, each pound of nitrogen required 3 pounds more of calcium oxid to attain an equal soil reaction; that is, 100 pounds of sulfate of ammonia required about 80 pounds of hydrated lime, or 120 pounds of limestone, more than was required by 128 pounds of nitrate of soda supplying the same amount of nitrogen. When completely oxidized, sulfate of ammonia supplying 1 pound of nitrogen would require for neutralization 4 pounds of calcium oxid. It is believed that this should be the basis of future liming to maintain the sulfate plat at the same reaction as the nitrate plat. The relative lime-response of the 22 different kinds of crops is expressed as low, medium, or high. Because the two extremely sensitive crops to acid-soil conditions, spinach and lettuce, tended to yield less with sulfate than with nitrate, determinations are included of the soil content of active alumina and of nitrate-nitrogen under the two conditions. In general, the crop yields were about alike with the two sources of nitrogen when the same reaction of the Merrimac silt loam was maintained.

AU: MacIntire, -W.H.; Shaw, -W.M.; Sanders, -K.B.

TI: The influence of liming on the availability of soil potash.

SO: J-Am-Soc-Agron. Madison, Wis. : American Society of Agronomy. June 1927. v. 19 (6) p. 483-505.

CN: DNAL 4-AM34P

PY: 1927

AB: It is pointed out that the results of laboratory interchange studies have served as the basis for unjustified assumptions that potassium will be liberated by calcium in the practice of liming. Evidence is cited to show that a neutral salt of calcium may liberate potassium to the leachings from an acid soil, but that the reverse effect results when supplementary additions of CaO or MgO are made. Studies were made of the present availability of the potash of three soils which had been subject to the influence of liming in plat studies extending over respective periods of 7, 17, and 21 years. Distilled and carbonated water, HCl (1.115), and 0.2 N HCl digestion and leachings to equilibrium with 0.05 N HCl and with N/1 NH₄Cl were used to measure the present availability of native and added potash as influenced by liming. In general the two dilute acid and NH₄Cl procedures gave comparable results without consistently showing a definite effect from liming, although indicating increase in potash reserve supplies where potash had been added. The two aqueous extraction procedures did indicate a definite decrease in availability of native and added potash as the result of liming. No indication of potassium liberation was adduced in

any case. The extraction studies were in line with the yields from those plats as given by Mooers. From a four-year supplementary lysimeter study upon the influence of surface and subsurface incorporations of $\text{Ca}(\text{OH})_2$ at four rates, high-magnesian lime, and five limestone and five dolomite constants upon native potash it was demonstrated that: (a) The surface-zone incorporations gave consistently greater yields, whereas the subsurface incorporations gave consistently lower yields, of leachable potash than were given by the untreated soil; (b) neutral calcium salts exerted no liberative effect in the zone of alkali-earth incorporation; (c) calcium salt leachings effected a potash liberation in the lower untreated acid zone; (d) progressive decreases in annual outgo were found; and (e) high-magnesian limes caused diminished potash outgo, irrespective of zone of incorporation. From a second supplementary lysimeter study relative to the influence of hydrated lime, that of ground limestone and that of dolomite (all equivalent to 1 ton of CaO), upon the fate of water-soluble potash added through clover cuttings, where all additions were mixed throughout the full depth of soil, it was found that: (a) Each unsupplemented alkali-earth addition resulted in a potash outgo less than that from the control; (b) the several incorporations so "fixed" the 70-pound potash increment from 2 tons of clover as to give an average outgo less than that from the no-clover soil; and (c) the 99-pound increase in potash outgo from the unsupplemented 8-ton clover incorporation, which supplied 280 pounds of K_2O , was reduced to an outgo of only 72 pounds as an average from the five lime treatments. It is pointed out that, when pH values indicate excess of H-ions, potash liberation is effected by neutral calcium salts and that the reverse, potash fixation, is brought about when H-ion concentration is greatly reduced, or superseded by OH-ion concentration, if the OH concentration is not so excessive as to induce hydrolysis of native potassic complexes, as the result of the practical liming of these particular soils. As differing from the interchange between native potash for added lime, through zone-of-incorporation conditions which permit such interchange, a new viewpoint is advanced, that of the value of liming in its capacity to conserve soluble potash additions in a form most probably available to plants, yet resistant to excessive loss through normal leaching.

SilverPlatter v 2.15 AGRICOLA (1970 - 1978)

AU: Weaver,-D-J; Wehant,-E-J
 TI: Control of peach tree short life with hydrated lime and soil fumigation
 SO: Proc-Annu-Conv-Natl-Peach-Counc, 1976, 35th: 52-53.
 CN: DNAL SB371.N3
 PY: 1976

AU: Anderson,-W-C; Gabrielson,-R-L; Haglund,-W-A; Baker,-A-S
 TI: Clubroot [*Plasmiodiophora brassicae*] control in crucifers with hydrated lime and PCNB
 [Pentachloronitrobenzene]
 SO: Plant-Dis-Rep, July 1976, 60 (7): 561-565.
 CN: DNAL 1.9-P69P
 PY: 1976

AU: Rodriguez-Geigel,-A
 TI: Hydrated lime; importance in tropical agriculture. [Fertilizers]
 SO: Sugar-J, Jan 1971, 33 (8): 10-13.
 CN: DNAL 65.8-SU391
 PY: 1971
 SilverPlatter v 2.15 AGRICOLA (1984 - 12/91)

AU: Starcher,-G.-C. (George Columbus)
TI: A stone-fruit spray made from hydrated-lime and sulphur.
SO: Blacksburg, Va. : Virginia Polytechnic Institute, Virginia Agricultural Experiment Station, 1916. 14 p.
CN: DNAL 100-V815-1-no.210
PY: 1916

AU: Vandevender,-J.C.; Sencindiver,-J.C.
TI: The effects of three forms of nitrogen fertilizer, phosphorus, and hydrated lime on abandoned mine land reclamation.
SO: Proceedings / 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, Dec 6-10, 1982 ; ed. G.H. Graves. Lexington, Ky. : Office of Engineering Serv., College of Engineering, Univ. of Kentucky, c1982. p. 497-502.
CN: DNAL TD195.S75S95-1982
PY: 1982
SilverPlatter v 2.15 AGRICOLA (1979 - 1984)

AU: Vandevender,-J.C.; Sencindiver,-J.C.
TI: The effects of three forms of nitrogen fertilizer, phosphorus, and hydrated lime on abandoned mine land reclamation.
SO: Proceedings / 1982 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, Dec 6-10, 1982; ed. G.H. Graves. Lexington, Ky. : Office of Engineering Serv., College of Engineering, Univ. of Kentucky, c1982. p. 497-502.
CN: DNAL TD195.S75S95-1982
PY: 1982

AU: Wehunt,-E.J.; Weaver,-D.J.
TI: Effect of planting site preparation, hydrated lime, and DBCP (1,2-dibromo-3-chloropropane) on populations of *Macroposthonia xenoplax* and peach tree short life in Georgia.
SO: J-Nematol. Ames.: Society of Nematologists. Oct 1982. v. 14 (4) p. 567-571.
CN: DNAL QL391.N4J62
PY: 1982

SilverPlatter v 2.15 AGRICOLA (1970 - 1978)

AU: Weaver,-D-J; Wehunt,-E-J
TI: Control of peach tree short life with hydrated lime and soil fumigation
SO: Proc-Annu-Conv-Natl-Peach-Counc, 1976, 35th: 52-53.
CN: DNAL SB371.N3
PY: 1976

AU: Anderson,-W-C; Gabrielson,-R-L; Haglund,-W-A; Baker,-A-S
TI: Clubroot [*Plasmodiophora brassicae*] control in crucifers with hydrated lime and PCNB [Pentachloronitrobenzene]
SO: Plant-Dis-Rep, July 1976, 60 (7): 561-565.
CN: DNAL I.9-P69P
PY: 1976

Effect of Bio-Cal and Other Common Calcium Soil Supplements on Biological Activity in Soil

Midwestern Bio-Ag Products and Services
Blue Mounds, WI

(supporting document for submission for organic approval status of Bio-Cal)
October, 2000

Bio-Cal is a source of highly 'plant available' calcium and sulfur that has been commonly used by conventional, transitional and organic farmers with great success for over 15 years. Bio-Cal has been shown to improve yield and uptake of major minerals important to animal nutrition. It has also been shown to improve soil calcium levels even on neutral pH soils.

Despite these important improvements in crop yield and quality, Bio-Cal has been not been listed as acceptable for organic production systems under new federal guidelines due to the calcium complex in Bio-Cal being associated with chemical characteristics of burnt lime. The concern is that it may have a detrimental effect on soil biology such as has commonly and historically been associated with burnt and hydrated lime. To date, no research has shown Bio-Cal to have anything but a positive effect on soil biology.

The caustic effect of burnt and hydrated lime on growing plants has been seen consistently by farmers when these products are directly applied to growing crops. Incomplete data exists on the effects of such calcium products on the organisms that comprise the soil's natural microbiology. Bio-Cal has not shown these negative effects on plants.

This study was designed to demonstrate the effects of three common calcium sources – calcitic limestone (calcium carbonate), burnt lime (calcium oxide) and Bio-Cal (calcium complex) – on soil microbiology.

Disintegration rate of cotton strips was used to simulate the effects on microorganisms responsible for crop residue recycling. A previous study actually showed improved residue recycling with Bio-Cal, however, sample numbers were not large enough to meet statistical criteria for significance.

Production of a known metabolite of soil microorganisms, formazan enzyme, has a commercially available testing procedure, and was used as a second measure of soil microbiology.

Finally, enumeration of specific classes of soil microorganisms was used to determine whether any detrimental effect was seen on normal microbial diversity. This process has become commercially available only recently, and most of this testing is still performed under research university settings.

Sites, Materials and Methods

In 1999, three sites were selected for this study. Site 1 was a research and demonstration farm with medium-textured, clay-silt-loam soils (C.E.C. 9-11) in southwestern Wisconsin. Site 2 was a garden with light-textured, sandy soils (C.E.C. 5-6) in central Wisconsin. Site 3 was crop farm with heavy-textured, clay soils (C.E.C. 18-19) in northeastern Wisconsin. Sites were chosen to provide a wide range of soil densities.

Each site was laid out in 4 x 4 design for a control plot, Bio-Cal plot, burnt lime plot and calcitic lime plot. Plots were 4 foot by 4 foot and were replicated diagonally across normal spreading and tillage patterns. Treatments were assigned randomly to a designated plot number and applied to the center area of each plot consisting of a 3 foot by 3 foot area. This was done to prevent cross application from plots and to ease tillage used to incorporate the treatments.

Treatments were applied at the rate of about 2 tons per acre (0.8 pounds per plot).

Treatment materials were incorporated into the surface with a rototiller. Two woven cotton strips were buried in the center of each plot. Starting weight of each strip averaged 43.2 grams.

Plots were kept weed free by using a hand held flame cultivator to burn young weeds 2 or 3 times during the test period. The test period lasted 50 days at site 1, 64 days at site 2 and 65 days at site 3. Test period length was determined by evaluating an indicator strip of cotton for significant decay, and probably varied for reasons such as level of biological activity inherent in the soil and soil moisture.

At the end of the test period, cotton test strips were carefully dug and any measurable pieces were collected and air dried. The remnants of the strips were weighed. Relative microbial activity was measured by comparing the decay of cotton between the treatments.

At the time of collecting the test strips, a soil sample was taken from each replicated plot at a site. Replicated plot samples were pooled to form a treatment sample. Pooled samples from site 1 were submitted for formazan test analysis at Midwest Laboratories, Omaha, NE.

The same procedure was used at each site, and pooled samples were sent to Dr. Elaine Ingham at Soil Foodweb, Inc. (now Oregon State University) to be analyzed for active bacterial biomass, total bacterial biomass, active fungal biomass, total fungal biomass and fungal hyphal diameter.

Statistical analysis was done on the replicated cotton strip decay results. Other results could not be replicated enough to utilize statistical analysis due to the high cost of testing procedures.

Data and Results

Cotton strip decay results are shown for each site in Table 1. Cotton strip decay for burnt lime application was reduced versus control at site 3 ($p=.02$), decay for burnt lime application was reduced versus Bio-Cal at site 3 ($p<.05$), and decay for calcitic limestone application was reduced versus control at site 2 ($p<.10$). No significant difference was shown for any other cotton strip decay rates for any other treatments ($p<.05$).

Formazan test results showed a general reduction in the level found for all plots when compared to the pre-study levels (see Table 2). This could be expected since spring time microbial activity is generally higher than mid summer activity. Interestingly, the control plot was found to have the lowest formazan level at the end of the trial.

Bacterial and fungal levels were quite variable among all the sites, and no consistent pattern in levels of active or total bacteria, active or total fungi nor fungal hyphal diameter could be shown for the plots.

Table 1.

Percent Digestion of Cotton Strips						
Site 1:						
	----- Replication -----					
Plot	1	2	3	4	Ave. Digestion	Standard Dev., s
Control	66.7	46.3	63.0	71.3	61.8	10.89
Bio-Cal	45.4	47.2	49.1	73.1	53.7	13.02
Burnt lime	48.1	58.3	87.0	65.7	64.8	16.48
Calcitic limestone	66.7	69.4	66.7	67.6	67.6	1.27
Site 2:						
	----- Replication -----					
Plot	1	2	3	4	Ave. Digestion	Standard Dev., s
Control	89.8	95.4	93.5	91.7	92.6 ^A	2.40
Bio-Cal	77.8	92.3	93.5	95.6	89.8	8.12
Burnt lime	81.5	92.6	81.5	99.1	88.7	8.70
Calcitic limestone	83.3	91.7	84.3	72.2	82.9 ^D	8.04
Site 3:						
	----- Replication -----					
Plot	1	2	3	4	Ave. Digestion	Standard Dev., s
Control	73.1	73.1	56.5	84.3	71.8 ^A	11.46
Bio-Cal	83.3	63.9	63.9	56.5	66.9 ^A	11.48
Burnt lime	43.5	39.8	51.9	59.3	48.6 ^{B,C}	8.73
Calcitic limestone	74.1	35.2	44.4	60.2	53.5	17.19
A, B denotes significant difference at p = .02						
A, C denotes significant difference at p < .05						
A, D denotes significant difference at p < .10						

Table 2.

Site 1 Formazan Test Results	
	Level Found (mcg/10 g:soil/day)
Pre-Study (entire site)	1,956
Plot	
Control	653
Bio-Cal	730
Burnt lime	725
Calcitic limestone	780

Discussion

Results of this study show no detrimental effect on soil microbial activity when the calcium complex found in Bio-Cal is applied to soil. Considering that, one can conclude that the calcium complex in Bio-Cal is safe for soil microorganisms.

Although a previous study using cotton strips showed an increase in microbial activity when Bio-Cal calcium complex was applied, this study does not confirm that improvement. This may be due to the unusually high level of Bio-Cal (2 tons / acre) used in this study. Typical applications range from 500 to 1000 pounds / acre for Bio-Cal.

At one site, calcitic limestone decreased cotton strip decay ($p < .10$). No explanation can be offered for this based on current agronomic knowledge.

Interestingly, the long-standing belief that burnt lime has an absolute negative effect on soil microbiology could not be decisively confirmed at every site. Only at one of three sites (heavy clay soil) did burnt lime show a statistically significant reduction in the rate of cotton strip decay. This may be due to the relatively high level of microbial soil activity present at all three of the sites chosen for this study. Also, continuous use of burnt lime may be necessary to demonstrate its detrimental effect on soil microbes, although the level of burnt lime used was generally higher than would be used at a single application.

The fact that burnt lime did show significant reduction in microbial activity at one site compared to both the control and Bio-Cal application shows that the calcium complex in Bio-Cal does not have the same caustic and detrimental effects as burnt lime. In fact, the results of this study show that of the three calcium treatments tested, only Bio-Cal did not have any negative impact on soil microbial activity despite being applied at four times the normal rate.

Based on the results of this and other studies, use of cotton strips and the rate of their decay appears to be an economical and reliable method of estimating soil microbial activity. Large variations in Formazan enzyme and microbial enumeration methods lead to questions as to the reliability of these two methods for measuring microbial activity. Using cotton strips may allow for overcoming the apparent variation in microbial dynamics of soil in an area as small as the rhizosphere, root zone or adjacent to a piece of organic matter.

Supporting Document
Bio-Cal™ Certified Organic Application

**Typical Effect of Bio-Cal™ Soil Application on Subsequent Mineral
Supplement Purchase for Dairies**

William A. Zimmer D.V.M.
Director of Research and Development
Midwestern Bio-Ag Products and Services, Inc.
June 14, 2001

Introduction

Bio-Cal™ is a liming material containing highly plant available forms of calcium and sulfur. One of the major benefits of Bio-Cal™ application has been the resulting increase in the uptake of all major minerals by forages and other crops grown on the Bio-Cal™ supplemented soil.

This supporting document includes two actual examples of the mineral content changes of forages that are typical using Bio-Cal™. It outlines what the improved mineral content of such forages means in terms of reducing the amount of mineral supplements needed to meet the nutritional needs of modern dairy cows. Reducing purchased and often synthetic origin mineral supplement need on organic farms is deemed beneficial for both the economic well being of the dairy as well as the organic philosophy of reducing the amount of synthetic substances in animal rations.

The comparisons below are for major mineral (calcium, phosphorus, magnesium, potassium and sulfur) content only. These five minerals account for approximately 50% to 75% of the minerals typically supplemented into dairy rations today. Salt represents the majority of the remainder. Trace minerals and vitamins typically represent less than 5% of the total supplement on a weight basis.

Not included in these examples is the difference in bioavailability of rock forms of mineral supplements versus organic forms found within plants. The feed industry has long looked at availability as a critical factor in the nutrition of animals. Mineral supplements that have been chelated to some organic compound such as protein have been developed to increase supplemental mineral availability. These chelated minerals have a relative availability closer to many plant forms of minerals.

To date, no published research that compares the availability of minerals at different levels within the same species of plant used as animal feed could be found. Logic would tell us that increased levels of a mineral within a plant would also correlate to increased availability of the mineral. This is due to known amounts of minerals being tied to either slowly or totally indigestible portions of plants (e.g. lignin).

Example 1

In this example, mineral supplement quantities will be calculated for an average of 295 mixed alfalfa forage samples documented by laboratory analysis as compared to all other mixed alfalfa forages tested by the commercial laboratory. The 295 samples are known to have received a balanced fertility program based around the use of Bio-Cal™. Additional nutrients may have been applied from commercial fertilizers and/or animal waste or crop residues. (Please refer to the attached chart titled Feed Test Comparison.)

Comparison is of MBA 1996-97 mixed alfalfa samples versus all 1995 Dairyland Laboratories mixed alfalfa samples. The different years are compared because MBA started analyzing nearly all of its samples at this laboratory in 1996. Its many samples are included in and may skew the values of all Dairyland Laboratories 1996 samples.

<u>Parameter</u>	<u>MBA samples</u>	<u>All samples</u>	<u>Change</u>
% Calcium	1.62%	1.10%	+ 0.52% points
% Phosphorus	0.36%	0.31%	+ 0.05% points
% Magnesium	0.37%	0.28%	+ 0.09% points
% Potassium	2.86%	2.57%	+ 0.29% points
% Sulfur	0.31%	0.24%	+ 0.07% points

For a ration containing an average total dry matter per cow of 50 pounds, 50% of which comes from the above alfalfa forages, the difference in mineral nutrition per cow per day would be as follows.

<u>Parameter</u>	<u>MBA samples vs. All samples Change</u>
Calcium, pounds	0.52% x 50 lbs. x 50% inclusion = 0.13 lbs./cow/day
Phosphorus, pounds	0.05% x 50 lbs. x 50% inclusion = 0.0125 lbs./cow/day
Magnesium, pounds	0.09% x 50 lbs. x 50% inclusion = 0.0225 lbs./cow/day
Potassium, pounds	0.29% x 50 lbs. x 50% inclusion = 0.0725 lbs./cow/day
Sulfur, pounds	0.07% x 50 lbs. x 50% inclusion = 0.0175 lbs./cow/day

Using the following common commodity feed mineral supplements, it would require the following amounts of each supplement to make up the difference for each mineral shown above every day.

<u>Supplement</u>	<u>Amount needed daily</u>
Calcium carbonate, 38% Ca	0.2442113 Lbs.
Dicalcium phosphate, 22% Ca, 18% P	0.0694444 Lbs.
Magnesium oxide, 58% Mg	0.0387931 Lbs.
Potassium chloride, 50% K	Already sufficient in ration.
Calcium sulfate, 23.3% Ca, 18.6% S	<u>0.094086 Lbs.</u>
Total	0.4465348 Lbs.

For a small 50 cow dairy, the amount of mineral supplement saved in a 365 day calendar year would be:

$$0.4465348 \text{ Lbs./cow/day} \times 50 \text{ cows} \times 365 \text{ days/year} = 8,149 \text{ Lbs. (4.07 tons) / year}$$

Example 2

In example 1, the fertility program may have included other fertilizer supplements besides Bio-Cal™, although these customers tend to make excellent use of animal manures and crop residues and already had moderately high soil fertility levels. For example 2, we will do the same mathematical calculations for two first crop alfalfa samples from side by side fields, the only difference between which is the spring application of Bio-Cal™ to one field. Both fields are extremely high in soil phosphorus and potash fertility. (Please refer to attached sheets titled Feed and Forge Report, #001446 and #001447, dated 6/5/96.)

<u>Parameter</u>	<u>MBA samples</u>	<u>All samples</u>	<u>Change</u>
% Calcium	1.48%	1.38%	+ 0.10% points
% Phosphorus	0.47%	0.43%	+ 0.04% points
% Magnesium	0.35%	0.32%	+ 0.03% points
% Potassium	3.99%	3.45%	+ 0.54% points
% Sulfur	0.32%	0.16%	+ 0.16% points

For a ration containing an average total dry matter per cow of 50 pounds, 50% of which comes from the above alfalfa forages, the difference in mineral nutrition per cow per day would be as follows.

<u>Parameter</u>	<u>MBA samples vs. All samples Change</u>
Calcium, pounds	0.10% x 50 lbs. x 50% inclusion = 0.025 lbs./cow/day
Phosphorus, pounds	0.04% x 50 lbs. x 50% inclusion = 0.01 lbs./cow/day
Magnesium, pounds	0.03% x 50 lbs. x 50% inclusion = 0.0075 lbs./cow/day
Potassium, pounds	0.54% x 50 lbs. x 50% inclusion = 0.135 lbs./cow/day
Sulfur, pounds	0.16% x 50 lbs. x 50% inclusion = 0.04 lbs./cow/day

Using the following common commodity feed mineral supplements, it would require the following amounts of each supplement to make up the difference for each mineral shown above every day.

<u>Supplement</u>	<u>Amount needed daily</u>
Calcium carbonate, 38% Ca	0.0 Lbs.
Dicalcium phosphate, 22% Ca, 18% P	0.0555555 Lbs.
Magnesium oxide, 58% Mg	0.012931 Lbs.
Potassium chloride, 50% K	Already sufficient in ration.
Calcium sulfate, 23.3% Ca, 18.6% S	0.2150537 Lbs.

Total 0.2835402 Lbs.

For a small 50 cow dairy, the amount of mineral supplement saved in a 365 day calendar year would be:

0.2835402 Lbs./cow/day x 50 cows x 365 days/year = 5,174 Lbs. (2.58 tons) / year

Discussion

In the above examples, the theoretical ration used consisted of 25 pounds dry matter alfalfa forage, 5 pounds dry matter corn silage, 20 pounds concentrate (grain / protein / mineral / vitamin). This represents 55% forage:45% concentrate assuming the corn silage to be well eared with approximately 50% grain content. Many rations successfully fed by Midwestern Bio-Ag customers, including organic dairies, consist of 60% to 65% dry matter forage, often exclusively from alfalfa forage. These rations would recognize an even greater benefit from increased mineral content of their alfalfa forage grown on Bio-Cal™ supplemented soil.

Rations containing 50% alfalfa forage would contain enough potassium to meet the requirements of high producing lactating dairy cows nearly all conditions. For this reason, potassium supplements were not added into the above calculations even though there was an increase in potassium content of alfalfa grown on Bio-Cal™ supplemented soils.

Sulfur is an important mineral in animal rations. Its main function is as part of amino acids that make up protein. Increasing the sulfur content of plants may result in increasing the sulfur containing amino acid content of the proteins. This gives a benefit far beyond the simple mineral value of sulfur. For the above calculations, sulfur was supplemented into the rations in sulfated mineral form. Ruminant animals have the ability to convert moderate levels of mineral sulfates into sulfur containing amino acids by the activity of the rumen microorganisms. Because sulfate minerals can also tie up other minerals, supplementing them at very high levels is not nutritionally sound. For example, supplementing over 0.05 pounds sulfur from sulfate would increase the ration sulfate concentration to over 3,000 ppm in the above rations. For this reason, the increased sulfur content of forages is even more valuable than the mineral supplement equivalent.

If a plant contains indigestible lignin, and the structure of that lignin contains a specific ratio of a mineral (e.g. calcium), then, as the total amount of calcium in the plant increases, the relative amount of available calcium actually increases faster than the absolute amount of calcium. For example, if an alfalfa plant contains 10% indigestible lignin with a ratio of 10% calcium bound within the lignin, then 1% of the total plant weight (10% lignin x 10% bound calcium) would be unavailable calcium. If the plant's total calcium is 1.15% by weight, then 0.15% (1.15% total - 1% lignin bound) or 680 mg calcium per pound of plant would be available. Relative calcium availability would be 13% (0.15% available / 1.15% total). What if we can grow this same plant in such a way as to raise the total calcium content to 1.5% by weight? This represents just a 30% (1.5% / 1.15%) increase in total calcium content of the plant, but the available calcium level increases to 0.5% (1.5% total - 1% lignin bound) of the total plant weight or 2,267 mg calcium per pound of plant. Relative calcium availability would be 33% (0.5% available / 1.5% total). Each pound of the higher calcium content plant would actually provide over 3 times more available calcium (2,267 mg / 680 mg).

Bio-Cal™ has shown a decade of results increasing the nutritionally required, mineral content of forage crops. Some of these increases have been even higher than those shown in the above examples.

Feed Test Comparison

Midwestern Bio-Ag Fertility Program vs. all other samples

Test	Average of Dairyland Labs Mixed Haylage Samples		Dairyland Labs Samples from Bio-Ag Farms With confirmed use of MBA fertility program		
	1995	1996	MBA 96-97	Change	MBA Desired level
Samples	N=16,662	N=19,984	N=295		—
Crude Protein %	19.39	19.57	20.50		18-21
Insoluble Protein %	1.82	1.81	1.62		—
Protein Solubility %	49.38	49.27	50.63		—
A.D.F. %	35.43	34.95	33.39		28-30
N.D.F. %	45.13	44.52	43.27		ADF + 15
Calcium %	1.10	1.15	1.62	+47%	>1.5
Phosphorus%	0.31	0.33	0.36	+16%	>0.35
Magnesium %	0.28	0.29	0.37	+32%	>0.35
Potassium %	2.57	2.70	2.86	+11%	1.5-2.0
Sulfur %	0.24% N+292	0.28% N=662	0.31% N=279	+ 29%	—
Nitrogen: Sulfur Ratio	13:1	11:1	10.5:1		10:1
Nitrogen%	3.1	3.13	3.28		—

M.Lovlien 8-97

500th Bio-Cal @ Green Up

FEED AND FORAGE REPORT

Report date: 6/ 5/96

REPRINT OF ORIGINAL
Sample number: 001446

TO: Bob Schmidtknecht
W26857 Mesa Lane
Arcadia, WI 54612

ACCOUNT # 554 (6)
SAMPLED BY: Bob Schmidtknecht

SAMPLED FOR: WOYCHIK BROS.

PRODUCT: #1 alfalfa (1A - N3)

RESULTS: Moisture 84.59%
Dry Matter 15.41%

	RY BASIS:	S	IS:		
Crude Protein	24.35%			3.75%	
A D F	30.89%			4.76%	
N D F	39.14%			6.03%	
AD-ICP (Bound Protein)	1.50%			0.23%	
Protein Solubility	31.58%	7.69 lb/cwt	31.58%	7.69 lb/cwt	
Calcium	1.48%	6.71 g/lb	0.23%	1.03 g/lb	
Phosphorus	0.47%	2.13 g/lb	0.07%	0.33 g/lb	
Magnesium	0.35%	1.59 g/lb	0.05%	0.24 g/lb	
Potassium	3.99%	18.10 g/lb	0.61%	2.79 g/lb	
Sulfur	0.32%		0.05%		

CALCS:	T.D.N.	64.84%	9.99%
	Adjusted Crude Protein	24.35%	3.75%
	N.F.C.	24.81%	3.82%
	N.E.L. (Mcal/cwt)	66.83	10.30
	N.E.- G. (Mcal/cwt)	40.01	6.16
	N.E.- M. (Mcal/cwt)	66.72	10.28
	D.D.M.	64.84%	
	D.M.I. (% Body Weight)	3.07%	
	R.F.V.	154.31	

ACCOUNTING INFORMATION

AIRYLAND LABORATORIES, INC. - Arcadia

SAMPLED BY: Bob Schmidtknecht
SAMPLED FOR: WOYCHIK BROS.
PRODUCT: #1 alfalfa

Invoice: 0104540
Date: 6/ 5/96
Sample: 001446

\$ 17.00 N3-NIR w/Sulfur
\$ 17.00 TOTAL INVOICE (THIS ANALYSIS WAS RE-PRINTED ON 6/ 6/96)

No Bio-Cal

FEED AND FORAGE REPORT

Report date: 6/ 5/96

REPRINT OF ORIGINAL
Sample number: 001447

TO: Bob Schmidtknecht
W26857 Mesa Lane
Arcadia, WI 54612

ACCOUNT # 554 (6)
SAMPLED BY: Bob Schmidtknecht

SAMPLED FOR: WOYCHIK BROS.

PRODUCT: #2 alfalfa (1A - N3)

RESULTS: Moisture 79.24%
Dry Matter 20.76%

RY BASIS: S IS:

Crude Protein	21.83%		4.53%
A D F	26.65%		5.53%
N D F	34.07%		7.07%
AD-ICP (Bound Protein)	1.24%		0.26%
Protein Solubility	22.90%	5.00 lb/cwt	22.90% 5.00 lb/cwt
Calcium	1.38%	6.26 g/lb	0.29% 1.30 g/lb
Phosphorus	0.43%	1.95 g/lb	0.09% 0.40 g/lb
Magnesium	0.32%	1.45 g/lb	0.07% 0.30 g/lb
Potassium	3.45%	15.65 g/lb	0.72% 3.25 g/lb
Sulfur	0.16%		0.03%

CALCS: T.D.N. 68.14% 14.15%
Adjusted Crude Protein 21.83% 4.53%
N.F.C. 32.40% 6.73%
N.E.L. (Mcal/cwt) 70.51 14.64
N.E.- G. (Mcal/cwt) 44.31 9.20
N.E.- M. (Mcal/cwt) 71.53 14.85
D.D.M. 68.14%
D.M.I. (% Body Weight) 3.52%
R.F.V. 185.93

ACCOUNTING INFORMATION

AIRYLAND LABORATORIES, INC. - Arcadia

SAMPLED BY: Bob Schmidtknecht
SAMPLED FOR: WOYCHIK BROS.
PRODUCT: #2 alfalfa

Invoice: 0104541
Date: 6/ 5/96
Sample: 001447

\$ 17.00 N3-NIR w/Sulfur
\$ 17.00 TOTAL INVOICE (THIS ANALYSIS WAS RE-PRINTED ON 6/ 6/96)

Comparison of Bio-Cal and Other Common Calcium Soil Supplements on Soil Fertility and Tissue Analysis of Soybeans

Midwestern Bio-Ag Products and Services

Blue Mounds, WI

(supporting document for submission for organic approval status of Bio-Cal)

November, 2000

Bio-Cal is a source of highly 'plant available' calcium and sulfur that has been commonly used by conventional, transitional and organic farmers with great success for over 15 years. Bio-Cal has been shown to improve yield and uptake of major minerals important to animal nutrition. It has also been shown to improve soil calcium levels even on neutral pH soils.

Despite these important improvements in crop yield and quality, the question remains – why use Bio-Cal instead of commonly available calcitic limestone or gypsum.

This study demonstrates the effects of three common calcium sources – calcitic limestone (calcium carbonate), gypsum (calcium sulfate) and Bio-Cal (calcium complex) – on soil fertility and plant tissue mineral analyses.

Sites, Materials and Methods

In 1995, two fields on the Midwestern Bio-Ag Learning Center farm were selected for this study. Field B9 and D3 are both medium-textured, clay-silt-loam soils (C.E.C. 8-12) typical of southwestern Wisconsin. Because of the underlying dolomite rock, soils in the region are high in magnesium. Years of agricultural production tend to leave soils with higher than desired magnesium levels and lower than desired calcium levels despite soil pH being in ranges generally accepted as desired for agronomic production. Both of these fields had high levels of phosphorus and potash fertility and neutral pH.

Each field was split into thirds and the various calcium products were applied to one third of the field. Both fields received uniform tillage, mainly in the fall, with final seed bed preparation using a Rotavator as the only tillage occurring in the spring. All areas of the field received a balanced crop fertilizer that included nitrogen, phosphorus, potash, sulfur and trace minerals applied in the row at planting each year. Corn fertilizer application rates were 300 to 350 pounds per acre of 15-8-2. Soybean fertilizer application rates were 200 pounds or either 12-9-3 or 15-8-2.

Treatments were applied prior to fall tillage each year at the following rates: calcitic limestone – 2000 pounds per acre; gypsum – 1000 pounds per acre; Bio-Cal – 1000 pounds per acre.

Data

Soil fertility levels for field B9 are shown in Table 1.

Soil fertility levels for field D3 are shown in Table 2.

Plant tissue mineral analyses for soybeans taken during the year 2000 growing season are shown in Table 3.

Table 1.

Field B9 Soil Fertility Analyses													
<u>1995</u>													
Treatment	Organic Matter	pH	Bray ----- ppm -----										
			P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
Limestone	1.9%	7.0	75	114	211	474	1447	10	2.8	17	51	1.0	1.0
Gypsum	2.8%	7.3	82	150	159	370	1443	16	4.2	17	47	1.0	0.7
Bio-Cal	2.5%	6.9	127	217	231	414	1535	12	4.4	16	43	1.3	0.7
<u>1997</u>													
Treatment	Organic Matter	pH	Bray ----- ppm -----										
			P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
Limestone	1.9%	7.3	87	153	206	447	1497	28	3.1	17	34	1.2	1.0
Gypsum	2.2%	7.3	75	131	170	384	1489	25	4.3	13	33	1.1	1.2
Bio-Cal	2.3%	7.4	105	153	193	367	1506	29	4.1	13	35	1.3	1.4
<u>1999</u>													
Treatment	Organic Matter	pH	Bray ----- ppm -----										
			P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
Limestone	2.0%	7.3	87	142	138	311	1402	10	3.3	15	34	1.1	1.0
Gypsum	2.0%	7.2	82	135	129	335	1469	29	4.0	16	31	1.1	1.1
Bio-Cal	2.1%	7.3	120	186	144	331	1525	19	3.9	18	35	1.4	1.6

Table 2.

Field D3 Soil Fertility Analyses													
<u>1995</u>													
Treatment	Organic Matter	pH	Bray ----- ppm -----										
			P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
Limestone	2.1%	7.2	72	110	197	344	1100	5	2.1	17	38	0.9	0.7
Gypsum	2.0%	7.1	73	107	205	297	1061	8	2.8	20	35	2.0	1.6
Bio-Cal	2.0%	7.2	81	144	182	334	1113	6	2.1	16	31	0.8	1.0
<u>2000-A</u>													
Treatment	Organic Matter	pH	Bray ----- ppm -----										
			P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
Limestone	1.7%	7.4	107	160	238	262	1393	7	2.4	9	29	1.2	0.7
Gypsum	1.7%	7.1	100	152	215	301	1284	27	2.9	13	27	1.1	0.6
Bio-Cal	1.9%	7.4	140	165	277	220	1516	14	3.0	15	26	1.1	1.3
<u>2000-M</u>													
Treatment	Organic Matter	pH	Bray ----- ppm -----										
			P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
Limestone	1.8%	7.4	100	134	211	335	1389	8	2.8	11	37	1.3	0.8
Gypsum	2.1%	7.1	92	121	208	306	1348	34	3.3	14	30	1.1	0.8
Bio-Cal	2.4%	7.4	112	156	212	296	1403	16	3.1	14	30	1.2	1.1

Table 3.

Plant Tissue Mineral Analyses Results													
Field B9													
Treatment	%						ppm						
	N	P	K	Ca	Mg	S	B	Zn	Mn	Cu	Fe	Al	Na
Limestone	4.45	0.25	1.71	0.92	0.45	0.21	35	29	72	33	661	560	261
Gypsum	4.61	0.35	2.47	1.33	0.61	0.31	35	37	108	30	735	559	205
Bio-Cal	4.36	0.39	2.64	1.35	0.60	0.30	49	36	98	23	692	598	201
Field D3													
Treatment	%						ppm						
	N	P	K	Ca	Mg	S	B	Zn	Mn	Cu	Fe	Al	Na
Limestone	4.63	0.39	2.34	0.88	0.35	0.25	39	34	53	11	258	159	218
Gypsum	5.19	0.51	2.60	0.87	0.35	0.29	42	44	80	14	340	206	309
Bio-Cal	4.74	0.54	2.63	0.90	0.36	0.27	43	36	57	8	182	110	184

Results

The soil fertility data show two distinct patterns. Soil bray phosphorus (P1 and P2) is highest on the soil that received Bio-Cal for both fields at every testing date. Soil calcium is highest on the soil that received Bio-Cal for both fields at every testing date.

The plant tissue mineral data show the same pattern as is seen with the soil fertility data, namely soybeans growing on soil receiving Bio-Cal were higher in phosphorus and calcium than plants grown on the other two treatments.

Discussion

Lack of replicated test plots restricts statistical evaluation of the results of this study. Rather, the results shown here are a snapshot in time that show interesting trends so far. This study shall continue for several more years to yield a long term chronological analysis of the effects of applying these calcium sources.

Changes in laboratory test formats over the years makes absolute result comparison over time somewhat difficult, especially for sulfur. Differences in laboratory results are evident from the data listed as 2000-A and 2000-M, which represent a split soil sample sent to two different laboratories. Despite the variable laboratory testing procedures, the same trends for soil fertility were seen for Bio-Cal versus the other calcium treatments. It is these trends that make Bio-Cal so desirable as a soil amendment.

Limestone has a long history as a beneficial liming material capable of increasing the pH of acidic soil. As carbonate neutralizes soil acid, calcium is released to be used as a plant nutrient. However, the calcium bond in calcium

carbonate is strong relative to other calcium bonds. For this reason, limestone is only a good source of 'plant available' calcium under acidic soil conditions.

Gypsum has recently shown good results at reducing salinity in certain arid, alkaline soils. It has also been used as a source of the plant nutrient sulfur, and to reduce soil magnesium levels where excesses are present. The results of this study do not support gypsum as reducing magnesium levels in soil versus the other treatments. Gypsum did tend toward higher levels of soil sulfur, but not consistently. Plant tissue sulfur levels were highest for plants grown on soils treated with gypsum, however, the crop fertilizer also contained sulfur. Gypsum is probably best suited as an amendment on very alkaline soils (pH > 8) due to its high sulfur content. This sulfur will tend to decrease soil pH with prolonged application of gypsum.

Bio-Cal appears to be the best source of 'plant available' calcium at soil pH levels common to most agronomic systems in North America (pH between 6.5 and 7.0). This study shows Bio-Cal raises soil calcium levels better than limestone or gypsum at neutral pH. This increased soil calcium was shown to directly relate to higher plant calcium. Since plants are the major source of calcium for livestock, Bio-Cal applied to the soil can indirectly improve animal nutrition and the economics of balancing animal rations.

Although Bio-Cal is not a source of phosphorus, soil phosphorus was consistently highest where Bio-Cal was applied. The reason for this is unknown, but could be a result of formation of calcium phosphate bonds in the soil. Calcium phosphate is a stable soil molecule, yet plants can utilize the phosphorus via cation exchange in the root zone and as a result of fungal hyphae transporting such forms of soil phosphorus to the plant as part of the symbiotic relationship this fungus has with plant roots. Whatever the reason, Bio-Cal's ability to increase soil phosphorus fertility and subsequent plant phosphorus levels are both beneficial attributes. Improved soil phosphorus without having to excessively apply phosphorus fertilizers or manure will help plant metabolism, growth and yields while minimizing the negative effects of eroding phosphorus entering water systems. Increased plant phosphorus levels will reduce the cost and waste of phosphorus supplementation in animal diets.

Why Bio-Ag fertilizers?

All fertilizers are not created equal. What makes Midwestern Bio-Ag fertilizers different?

1. All the required elements. MBA fertilizers have a balance of ALL the nutrients needed for optimum plant growth, yield and quality. This means more than just N, P, and K, because crops need more than just those three elements. Crops also need calcium, sulfur and all the trace minerals, plus carbon and sugar to feed the soil microbes.

Bio-Ag fertilizers have guaranteed levels not just of N-P-K, but also the trace minerals sulfur, calcium, boron, copper, manganese and zinc.

2. Soluble and slow release All the desirable nutrients in the world may be present in a fertilizer, but if they are unavailable to the plant when the plant needs them, the crop will suffer.

Plants require different amounts of different nutrients at different times during their growth cycles. Most fertilizers are highly soluble. That means the nutrients are available at or near the time of application, but days, weeks or months later when the plant also needs them, they may be in short supply. The slow release nutrients hang around in the plants' root zone longer, so they are ready for the plants to use later in the growing season.

A combination of both quick release and slow release ensures all the necessary elements will be available when the crop needs them.

3. Fertilizer pH The pH of fertilizer affects the availability of nutrients. Yes, nutrients are present in the fertilizer you just bought, but are they present in a form the plant can use?

The pH of fertilizer plays a key role in its availability. Fertilizers in the 5.5-6.5 pH range are more available to the plant with less chance of them being tied up in the soil.

4. What else is in your fertilizer? Fertilizers need to be made from high quality, non-toxic and non-harmful ingredients.

Fertilizer materials are rarely found in nature in a pure form. Most ingredients come in a combination, linked with other natural or synthetic materials. When you buy a ton of fertilizer, you are not just purchasing 2,000 lbs of the nutrients you intended to add to your soil.

Fertilizers contain other elements that are tied up with the desired elements, and some of those can be more than just expensive and useless, they can actually damage the crop, especially in excesses. A fertilizer shouldn't harm the soil, soil life and plant roots. For example, high levels of salts and ammonia, found in some fertilizers, can have a negative effect on the whole soil system.

While you are adding those nutrients your crop needs, you may also be adding other things you definitely don't want. The truth is, you can have too much of a good thing. Excesses of elements can be as harmful as deficits.

For example muriate of potash

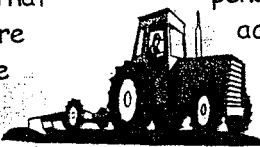
(KCl, 0-0-60) adds potassium, but also adds salt and chloride. Salts can burn roots and kill soil life. Many crops are also sensitive to chloride (potatoes, corn and soybeans, for example). While the excess chloride does eventually leach out of the root zone, it also takes desirable nutrients, like calcium, with it.

We carefully choose the sources of the materials we use in our fertilizers. We look at pH, solubility, soil building as well as flow characteristics, and quality control aspects of the supplier. An example of these criteria include our choices for nitrogen from ammonium sulfate from the textile industry, over urea or anhydrous ammonia.

Another example would be our choice of MAP over DAP. We frequently choose Calcium Sulfate over Calcium Carbonate or Dolomitic Lime when we want sulfur or when magnesium levels are already too high. In the case of trace minerals, we prefer the sulfate forms of manganese, zinc and copper over the oxide forms. When the farmer is certified organic, we take additional factors into account.

5. Fertilizer processing An important aspect to consider when buying fertilizer is the blending capability of the facility shipping the product. At Bio-Ag we take care to ensure that particle size and density for all ingredients meet the "sieve" test to ensure uniform mixing and thereby uniform application. In addition, all

(Continued on page 2)



....Gary's fall letter continued

(Continued from page 1)

tainly wonderful when the problems aren't there. Being on the treadmill of pushing cows, battling sick cows and buying inputs with this low milk price just can't be fun.

Biological farming appears to me to be the best method going: lower feed costs, lower vet bills, extra cattle to market due to lower turn over, reduced fertilizer and chemical bills with increased forage acres, healthier soil, better nutrient and manure management with the tight rotation, and possibly even some controlled grazing for reduced harvest costs. Finally, it's a system that's much friendlier for the environment, with fewer row crops, less commercial fertilizers, healthier soils, better manure management and less chemicals.

What if you are a grain farmer? This is still the best option. Balancing soil minerals, getting soils healthy and reducing commercial fertilizers and chemicals while maintaining or increasing crop yields is a great challenge to take on, and is being done successfully. It can certainly put the profit and the fun back in farming.

You are in this for the long haul and moving your input dollars to areas that improve your soil and your future seems logical. And that does not mean using more salt fertilizers, nitrogen and chemicals. Then, when bad crop

years come, as they will, healthy mineralized soil is your best insurance. Now you have better yields when the prices are up.

Confused or want some more ideas and/or assistance? Do let us know.

Farming is the same all over. I just returned from a lecture tour of Australia. There, grain is cheap, milk has been deregulated and prices are low, fuel prices are up, conditions are extremely dry, and there are more water use restrictions. I can see no alternative for them except biological farming.

This is not a fix it overnight program, but the farmers who have

been working in this direction are sure glad they did. Just like organic, the ones biologically/organically farming now are proud of how they farm and are making money. Assume we'll see more organic growth into the future.

If you are not sure what this biological farming really is or if it sounds too good to be true, I understand. That's why we have our field days and the model farm program. Visit those successful farms, ask, learn, then react.

I want to thank all the farms across the country that opened their operations for others to learn. As I always comment, if you could travel with me for a year, you would certainly do some things differently on your own farm.

"Learning from books and research is only one method, observing and visiting successful working farms is another."

Learning from books and research is only one method, observing and visiting successful working farms is another. This winter at my meetings I will share stories from these farms and others, not only in the U.S. but also in Australia and Canada. It's the same all over: it doesn't matter what crop you grow or where you live, it takes an abundance of minerals, water, sunshine and soil life to produce healthy high yielding crops.

I hope the fall harvest went well for you and do remember that fall is the time for soil correctives.

Gary Zimmer

....Fertilizers

(Continued from page 8)

Bio-Ag fertilizers are treated with soy-oil to reduce dust and improve flowability.

6. Fertilizer form Our Wee-Mix process ensures trace elements are applied evenly. Wee-Mix is a completely homogenized blending of ingredients so that even the smallest elements in a fertilizer will be applied everywhere they are needed. That's especially important with trace elements which are applied at low rates (1/2-5 lbs. per acre.) Pelleted distribution systems mean some plants will get the needed nutrients because a pellet is dropped nearby, others get nothing. It's hit or miss.

All of these characteristics combine to make Midwestern Bio-Ag fertilizers unique, cost effective, balanced fertilizers to help you produce healthy, high yielding, nutritious crops.

Why Bio-Cal?

"Calcium is the key to building soil fertility," says Gary Zimmer.

Why is Calcium important?

Even though it is called a secondary element, calcium has many important functions.

☑ Calcium is needed at high levels by plants. Plants need a continuous supply of calcium for growth and quality. It is a vital element in plant growth and health,

involved in building cell walls and cellular membranes,

cell division, and preventing invasion by disease pathogens.

☑ Calcium stimulates beneficial soil organisms, including earthworms and microorganisms such as bacteria, actinomycetes and fungi.

☑ Calcium improves soil structure. It loosens soil and causes the tiny soil particles to aggregate or clump together. Aggregated soils have more pore space, so they hold water and air better. They drain better and absorb moisture faster, reducing erosion; are easier to till; and reduce compaction.

☑ "The trucker of all minerals," calcium makes other nutrients more available. It raises the CEC or Cation Exchange Capacity, a measure of the soil's ability to store and release nutrients.

☑ Midwestern Bio-Ag recommends ideal calcium levels of 1,500-2000 ppm or higher, as well as Calcium to Magnesium (Ca to Mg) levels of 5:1 to 7:1.

Why is additional calcium needed?

In the midwest, calcium is often a limiting factor. Leaching moves calcium out of the root zone. Overuse of nitrogen and/or salt fertilizers leads to acidity or ties-up the calcium.

Legume crops can take from 100-250 lbs./acre per year of calcium, corn and grass crops 15-40.

Even soils that show adequate calcium on standard tests may not have enough readily available calcium for optimum plant growth all season long.

Most commonly used liming materials contain calcium, so the myth has grown that calcium neutralizes acidity. That is not true. The most important result of liming soil is not neutralizing acidity but replacing the nutrients that have been depleted by crops or lost via leaching.

What is Bio-Cal?

Bio-Cal, a proprietary product of Midwestern Bio-Ag, is a liming material and soil corrective that supplies significant amounts of readily available calcium, sulfur and other nutrients required to grow healthy, high yielding crops. Bio-Cal contains 28-36 percent calcium, plus 6-12% sulfur, and boron.

It is made from high quality sources of lime kiln dust, ash from coal fueled furnace combustion, quarried gypsum (calcium sulfate), and quarried limestone (calcium carbonate). The special blending and hydration process changes and improves the characteristics of the raw materials. Processing changes some of the calcium into a highly available form of calcium, calcium hydroxide. Bio-Cal also contains calcium in the form of calcium silicate, calcium sulfate and calcium carbonate. This combination gives us desirable levels of both highly available and slow release calcium. The raw materials are all blended, crushed and screened.

Bio-Cal meets all established levels set by state and federal agencies for all contaminants (heavy metals, dioxins and other compounds) for land applied products. Tested extensively, Bio-Cal has been found to be very clean compared to other byproducts, and is as safe or safer than naturally mined materials.

What is the history of Bio-Cal? Midwestern Bio-Ag developed the Bio-Cal product as the best calcium source on the market over 15 years ago.

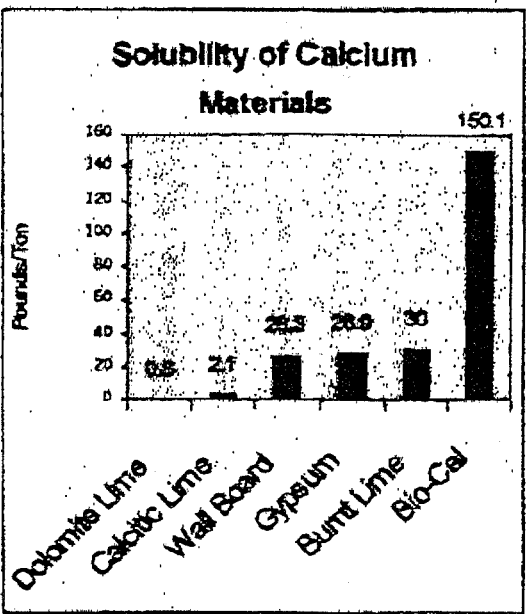
Since then well over 200,000 tons have been applied to farm fields with excellent results. The product has been refined over the years as well, and although alternative products have popped up in the marketplace, nothing has performed as consistently in getting calcium to plants.

How is Bio-Cal different from other products?

Bio-Cal contains calcium in a form that is highly soluble and readily available to plants. Research indicates up to 150 lbs. of soluble calcium per ton of Bio-Cal, compared to quarried limes

Why Bio-Cal?

- *Highly soluble means readily available
- *Proper calcium to sulfur ratios
- *Can be incorporated or top dressed
- *Ideal calcium source for all soil pH's



with 5 lbs. or less per ton.

By comparison, high calcium lime is slower acting, requires more and often is not locally available. Dolomitic lime is hard stone and slow (up to 18 months) to become available to the plant, and contains high magnesium. Papermill sludge, where available, is hard to handle and often not sufficiently processed. Liquid lime is more expensive. Additionally, gypsum shouldn't be used on low pH soils, if calcium base saturation is less than 60%.

Midwestern Bio-Ag does not recommend that any client use unprocessed kiln byproducts that contain high amounts of calcium oxide. These can

(Continued on page 7)

.... Why Bio-Cal

(Continued from page 9)

have deleterious effects on soil and crops. Do not confuse quick lime or burnt lime with Bio-Cal.

One field test study on the value of using Bio-Cal was conducted in 1995-97, comparing results from 295 MBA Fertility Program (including the use of Bio-Cal) haylage samples versus 35,000 other samples tested by Dairy-Land Labs over two years. The MBA farms showed calcium levels 47% above the others, at 1.62 (meeting the MBA desired feed level) of 1.5 or above) vs. averages of 1.10 and 1.15 on conventional farms. MBA farms also averaged higher in phosphorus (by 16%), Magnesium (by 32%), sulfur (by 29%), and potassium (by 11%).

Bio-Cal is an excellent and proven product for farmers who want to increase the amount of available calcium in their soils and in their crops. For more information about Bio-Cal, contact MBA at 1-800-327-6012.

Midwestern Bio-Ag Products and Services, Blue Mounds, Wisconsin

"Nutrition from the Soil Up"

Test	Average of Dairyland Labs Arcadia, Wisconsin Mixed Haylage Samples		Dairyland Labs Samples from Midwestern Bio-Ag Farms with Confirmed Use of MBA Fertility Program:		
	1995	1996	MBA 96-97	Change	MBA desired levels
Samples	n=16,662	n=19,984	n=295		
Crude Protein %	19.39	19.57	20.50		18-21
Insoluble Protein %	1.82	1.81	1.62		
Protein Solubility %	49.38	49.27	50.63		
A.D.F. %	35.43	34.95	33.39		28-30
N.D.F. %	45.13	44.52	43.27		A.D.F.+15
Calcium %	1.10	1.15	1.62	+ 47%	>1.5
Phosphorus %	0.31	0.33	0.36	+ 16%	>0.35
Magnesium %	0.28	0.29	0.37	+ 32%	>0.35
Potassium %	2.57	2.70	2.86	+ 11%	1.5-2.0
Sulfur %	0.24 (n=292)	0.28 (n=662)	0.31 (n=279)	+ 29%	
Nitrogen:Sulfur Ratio	13:1	11:1	10.5:1		10:1
Nitrogen %	3.1	3.13	3.28		

***A Healthy, Mineralized Plant
provides better livestock nutrition!***

mloveler/bioag2/pub/8/97

Improve Potato Yields, Quality and Profits Through Calcium

by Melissa Lake

Gary Zimmer knows a lot about dirt-soil, that is, in fact, he is the author of a book on the subject called *The Biological Farmer* published in 1999.

A biochemist, Zimmer and three partners own and operate Midwestern Bio-Ag (MBA), a farm research and education center in Blue Mounds, Wisconsin, specializing in soil improvements. The corporation, with 50 specialized consultants, works with more than 5,500 farmers.

Included in that number are, of course, potato farmers. For years, the notion of adding calcium to the soil was greeted with skepticism by potato farmers. It wasn't until the 1980s that potato farmers came to recognize that mid-to-late-season calcium applications can improve potato yields, quality, and profits.

According to Zimmer, calcium, though a secondary element, can:

- Build cell walls and cellular membranes.
 - Contribute to cell division.
 - Prevent invasion of disease pathogens.
 - Stimulate beneficial soil organisms, including earthworms, and microorganisms, such as bacteria, actinomycetes, and fungi.
 - Improve soil structure by loosening soil, causing aggregate to clump together.
- "Calcium is the key to building soil

fertility," Zimmer said. "It's the trucker of all minerals. By making calcium more available, it increases the soil's CEC (Cation Exchange Capacity) which is a measure of the soil's ability to store and release nutrients."

Problem is, calcium is often a limiting factor, particularly in the Midwest. Leaching moves calcium out of the root zone. Overuse of nitrogen and/or salt fertilizers leads to acidity or ties up the calcium. Even soils with adequate calcium on standard test may not have enough readily available calcium to sustain optimum plant development for an entire growth season.

So about 15 years ago, MBA developed Bio-Cal, a liming material and soil corrective made up of 28-36 percent calcium, plus sulfur and boron, which produces healthy, high-yielding crops.

"Bio-Cal is made from high-quality sources of lime kiln dust, ash from coal-fueled furnace combustion, quarried gypsum (calcium sulfate) and quarried limestone (calcium carbonate)," Zimmer said. "The special blending and hydration process changes and improves the characteristics of the raw materials."

The combination of calcium hydroxide, silicate, and carbonate creates both highly available and slow-release calcium. A mixture of

blended, crushed, and screened raw materials, Bio-Cal contains calcium in a form that is highly soluble and readily available to plants.

"There are 150 pounds of soluble calcium per ton of Bio-Cal, compared to quarried limes with 5 pounds or less per ton," Zimmerman said. "And high-calcium lime is slower acting, requires a heavier application and often is not locally available. Dolomitic lime is hard stone and takes up to 18 months to become available to the plant."

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Heartland Farms, Hancock, has been measuring a similar increased mineral uptake in potatoes based on the petiole test. Phosphorus was particularly high. What does this mean?

"Because of more mineral uptake, we would expect healthier, higher-

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yielding potatoes." Zimmer said. "With greater mineral up-take from the soil, we should be able to reduce fertilizer applications."

Since its development, more than 200,000 tons of Bio-Cal have been applied to farm fields.

For more information about Bio-Cal, contact MBA at 1-800-327-6012, or Norbert Hiess, the MBA Stevens Point representative, at (715) 592-4468. ♦



Gary Zimmer says calcium is the key to building soil fertility.

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To Bill from *Meeker*
Test Plots Show Not All Calcium Is the Same

by Gary Zimmer

As time goes by and we complete more and more test plots and get experience with trying various calcium materials, some trends become obvious.

Not all calcium sources perform the same, and soil tests, soil type and soil conditions indicate which type fits best. It is true in America and also in Australia as was clearly pointed out on my recent tour.

In summary, if your soil pHs are low, lime the soil and choose the liming material that fits your soils.

If you have a high magnesium soil use a high calcium lime. If you have a low magnesium soil and pH is low, you could use dolomite lime. In Wisconsin, except for real sandy soils, most farmers need high calcium lime.

If the pHs are fine, 6.7 or so and up, and you still need calcium, then lime is a poor choice. A higher soluble, more fertilizer grade fits best and extra sulfur

is essential under these conditions. This situation fits most Wisconsin farmers and Bio-Cal, a product manufactured for Midwestern Bio-Ag, performs the best. At rates of 500 to 1,500 lbs/acre, results are obtained.

What results? At our farm again this year we see the same results. For the past six years I have been comparing high calcium lime, gypsum (a calcium sulfur source) and Bio-Cal, a fine ground product with some sulfur and high soluble calcium levels. One section of this plot gets a ton of lime, another gets 1000 lbs of gypsum and the third gets 1000 lbs. of Bio-Cal. This is a corn-soybean rotation plot. I test plant tissue mineral levels, monitor soil tests and check crop quality and yield.

I will report the full data at my winter meetings, but in summary, on soybeans, the Bio-Cal plants tested are higher in most mineral levels. For example, tests show phosphorus at .54 compared to .39 for lime, and they are

lower in iron, aluminum and sodium levels. Do you know what that can do to feed quality and livestock production?

As for soils, I see the same trend: higher levels of phosphorus, calcium, potassium, and most trace elements.

One real noticeable trend is the organic matter. It is testing at 2.4% for the Bio-Cal areas and 1.8% for the lime area. In the beginning, the whole field averaged 1.8. The limed areas saw no change in Organic Matter but the Bio-Cal levels keep getting higher.

The gypsum plot results are almost in the middle. They show improvement over the high calcium lime but are not as good as the Bio-Cal area. These soils are sandy loams with a 7.0 pH and had high magnesium, low calcium levels.

I will be showing the complete test results at my winter meetings.

....Bio-Vet: Get Livestock Ready for Winter

(Continued from page 7)

system to get the digestive process started. As animals change feed types, different enzymes become important. Bio-Vet includes a broad complement of enzymes to work with all components of a livestock diet.

Yeast and Yeast Culture promote the process of fermentation and produce B vitamins and enzymes in the rumen. Yeast culture contains metabolites that feed beneficial rumen microbes promoting a more stable and healthy population. This more stable population of rumen bacteria can help animals that are experiencing a change

in feed. Bio-Vet utilizes yeast and yeast culture in microbial products fed daily for ruminating livestock.

In general, direct fed microbials improve dry matter intake, stabilize the digestive system resulting in a more consistent appetite. The net gain is fewer animals with inconsistent feed intake. This leads to improved efficiency and use of feed.

Vaccination: Fall is the time of the year to review your vaccination program with your veterinarian. Selective use of Pasturella vaccine and other bacterias may be considered in the fall. Review and vaccinate to help prevent

livestock respiratory infections.

Vaccinations for reproductive diseases such as leptospirosis are important in the fall. Rodents and wildlife are carriers of these diseases and can transmit them to livestock. Rodent control around your farm can aid in prevention. Vaccinating farm pets is also an investment that can prevent potential transmission of unwanted diseases.

Ventilation: Fall is the time of the year to prepare for proper ventilation during the winter months. Proper ventilation can improve the overall level of health in a livestock operation.

Not all calcium sources are the same:

Bio-Cal:

--Provides more immediately plant available calcium per ton than gypsum and other liming products. Research indicates up to 150 lbs. of water soluble calcium per ton of Bio-Cal, compared to quarried limes with 5 lbs. or less.

--Does not appreciably raise pH.

-- Lower cost when compared to liquid Calcium Nitrate.

--Highly soluble and available compared to standard liming materials. High calcium lime is slower acting and provides only 26 lbs. of calcium. Dolomitic lime can take up to 18 months to become available to plants.

-- Contains other valuable nutrients

--sulfur

--trace elements

--Over 200,000 tons of Bio-Cal has been used by farmers over the past 15 years, on all types of crops, in several states including Wisconsin.

--Many farmers report reduced need for N-P-K when using Bio-Cal.

How does Bio-Cal compare with Calcium Nitrate?

-- Lower cost

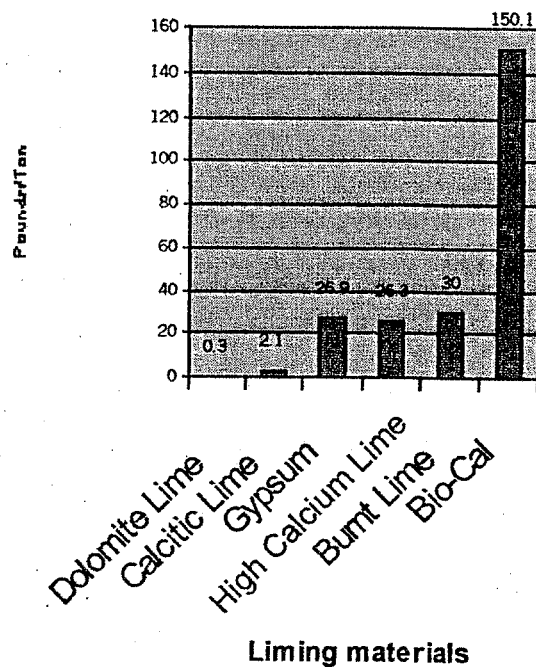
-- Contains extra nutrients

--sulfur

--trace elements

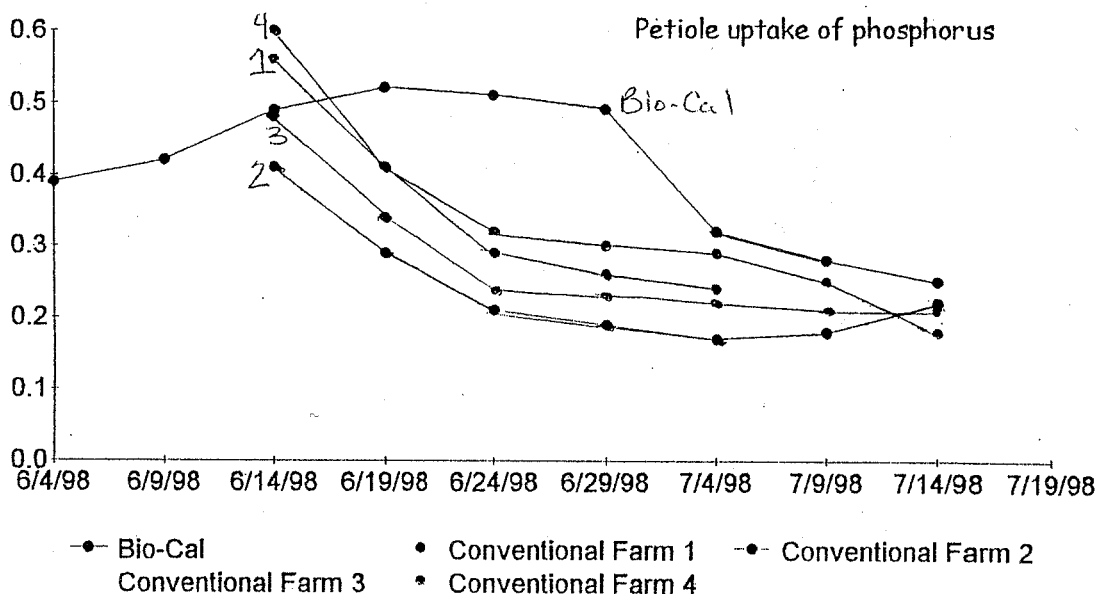
-- Studies show improved phosphorus uptake

Solubility of Calcium Materials



	Bio-Cal
Total Calcium	30-34%
Soluble Calcium	Up to 10%
Calcium Oxide	8%
Sulfur	4-6%
Magnesium	Less than 2.0%
Potassium	0.1%

Studies show Bio-Cal significantly improved phosphorus uptake



Note- Conventional farm defined as farm using calcium nitrate versus Bio-Cal

Research

--Petiole tests have shown increased phosphorus uptake in potatoes

--One recent on-farm study on a Wisconsin potato farm indicated that Bio-Cal was more effective in raising phosphorus levels compared to other conventional products

--The same study also showed increased potassium uptake associated with the use of Bio-Cal on potatoes.

--Increased calcium uptake in forages

--A study on calcium uptake in forages showed haylage from alfalfa fields on the Midwestern Bio-Ag program, which included Bio-Cal, had calcium levels 47% above other samples tested, magnesium levels were 32% higher, potassium levels were 11% higher, and sulfur 29% higher. (Feed Test Comparison Study by Mike Lovlien/Dairyland Labs 8-97)

Improve Potato Yields, Quality and Profits Through Calcium

By Melissa Lake
Published in
The Badger Common Tater
October, 2000

Gary Zimmer knows a lot about dirt—soil that is. In fact, he is the author of a book on the subject called *The Biological Farmer* published in 1999.

Zimmer and three partners own and operate Midwestern Bio-Ag (MBA), a farm research and education center in Blue Mounds, Wis., specializing in soil improvements. The corporation, with 50 specialized consultants, works with more than 3,500 farmers.

Included in that number are, of course, potato farmers. For years, the notion of adding calcium to the soil was greeted with skepticism by potato farmers. It wasn't until the 1980s that potato farmers came to recognize that mid- to late-season calcium applications can improve potato yields, quality and profits.

According to Zimmer, calcium, though a secondary element, can:

- Build cell walls and cellular membranes.
- Contribute to cell division.
- Prevent invasion of disease pathogens.
- Stimulate beneficial soil organisms, including earthworms and microorganisms such as bacteria, actinomycetes, and fungi.
- Improve soil structure by loosening soil, causing aggregate to clump together.

“Calcium is the key to build-

ing soil fertility,” Zimmer said. “It’s the trucker of all minerals. By making calcium more available, it increases the soil’s CEC (Cation Exchange Capacity) which is a measure of the soil’s ability to store and release nutrients.”

Problem is, calcium is often a limiting factor, particularly in the Midwest. Leaching moves calcium out of the root zone. Overuse of nitrogen and/or salt fertilizers leads to acidity or ties up the calcium. Even soils with adequate calcium on standard test may not have enough readily available calcium to sustain optimum plant development for an entire growth season.

So about 15 years ago, MBA developed Bio-Cal, a liming material and soil corrective made up of 28-36 percent calcium, plus sulfur and boron, which produces healthy, high yielding crops.

“Bio-Cal is made from high quality sources of lime kiln dust, ash from coal-fueled furnace combustion, quarried gypsum (calcium sulfate) and quarried limestone (calcium carbonate,” Zimmer said. “The special blending and hydration process changes and improves the characteristics of the raw materials.”

The combination of calcium hydroxide, silicate and carbonate creates both highly available and slow release calcium. A mixture of blended, crushed and screened raw materials, Bio-Cal contains calcium in a form that is highly soluble and readily available to plants.

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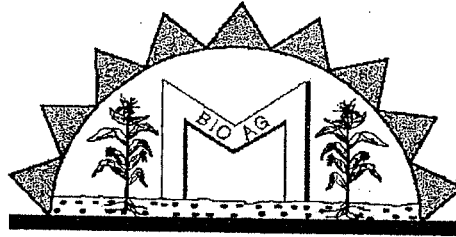
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“The MBA farms showed calcium levels 47 percent higher than the others with a feed test level of 1.62—well above the MBA benchmark of 1.5 and/or the 1.10-1.15 averages of conventional farms,” Zimmer said. “The MBA farms also averaged 16 percent higher in phosphorus, 32 percent higher in magnesium, 29 percent higher in sulfur and 11 percent higher in potassium.”

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“Because of more mineral uptake, we would expect healthier, higher-yielding potatoes,” Zimmer said. “With greater mineral uptake from the soil, we should be able to reduce fertilizer applications.”

Since its development, more than 200,000 tons of Bio-Cal has been applied to farm fields.



MIDWESTERN BIO - AG

What is Bio-Cal?

Bio-Cal® has been used by conventional, transitional and organic farmers with great success for over 15 years. Bio-Cal has been shown to improve yield and uptake of major minerals. It has also been shown to improve soil calcium levels even on neutral pH soils.

Bio-Cal is a soil amendment product that supplies significant amounts of Calcium, Sulphur and other nutrients. Bio-Cal® is registered in the State of Wisconsin as a liming agent. Lime is calcium carbonate. Bio-Cal is manufactured from lime kiln dust, ash from coal-fueled furnace combustion (all sources are screened for and meet EPA standards for heavy metal content), quarried gypsum (calcium sulphate), and quarried limestone (calcium carbonate).

Bio-Cal's special manufacturing process modifies and improves the characteristics of the original raw materials for agricultural use. The product is a combination of calcium oxide, calcium hydroxide, silicate, and carbonate. Unlike other liming materials, Bio-Cal provides a source of highly soluble Calcium, readily available to plants, as well as slow release Calcium.

Why do potato growers use Calcium?

- Improves Yields
- Improves Storage Life
- Increases Tuber Quality and Specific Gravity
- Improves Soil Structure & Aeration
- Stimulates Beneficial Soil Organisms: earthworms, bacteria and fungi
- Reduces Erosion and Compaction
- Increases Resistance to Disease Pathogens
- Increases Resistance to Insect Pests
- Combats Heat Stress
- Less Bruising During Handling
- More & Bigger Potatoes per Hill
- Less Brown Spot and Hollow Heart
- Improved Sprout Growth

What Farmers Are Saying About Bio-Cal

In our continuing effort to obtain organic certification for Bio-Cal, we surveyed farmers using Bio-Cal for 3-9 years on alfalfa, pasture, corn, soybeans and small grains, and were pleased with the resulting comments:

Matt Messa

"We sell a lot of hay which gets tested. The mineral levels in the hay have risen. Bio-Cal is the one product that we can document improvement. Our ton/acre yields have steadily improved since using it. We sell our hay by weight so it all gets weighed. This is very definitive for us."

Joe Hemmersbach

"The calcium levels are coming up. I know I don't have to buy as much minerals and protein. The soil trace minerals show higher."

Paul Klinkner

"Sulfur went up from .18 to .38 making the protein in my crops more available. Calcium in haylage has gone up to 1.79 from 1.07. Trace minerals have gone higher."

Tim Byom

"We have seen a definite increase in mineralization especially in calcium and sulfur which means less need for purchased protein. Calcium levels are higher in both the soil and feed. This makes the Calcium more available to our cattle. Feed tests are generally 1.25-1.50 now. Our new alfalfa seedings have improved by establishing the crop easier and for longer periods of time. Overall feed quality is better and it has helped with fewer weeds in our corn fields."

Tom Bagnewski

"Better yield, better quality and longer lasting stands" Soil tests show increases in all nutrients and feed tests have "higher calcium, phosphorus and magnesium with a very good increase on sulfur."

Gregory Hetrick

"Increase of all nutrients especially on our higher fertility soils" according to soil tests. Calcium levels show a significant difference: "high test minerals, better energy, even when made later." Overall, "better yields, higher quality, higher traces and minerals, better utilization of protein."

Dennis Hetrick

"Higher and much better testing forages" plus soil tests show "higher trace minerals, higher calcium levels, higher organic matter levels"

Anthony George

"Forage certainly fed better and ground was looser.

Better yield, better quality forage, longer lasting standing, had 2% calcium haylage."

Frank Berg

Calcium went up from 1.27 to 1.9. Soil tests show "calcium was some higher and we seemed to have a release of all other nutrients especially in our heavier soils, clays."

John Lisowski

"Calcium and all nutrients ran higher. Could visually see the difference in fields, darker color and taller. Better yield, better quality."

Greg Thomas

"Calcium has increased significantly have many tests that are now testing 1.7 to 2% calcium. All (soil) tests show higher available minerals. Better yield, dark color alfalfa, solid stem alfalfa, higher quality, stands last longer."

Patrick George

"The soil trace minerals show higher because of the breakdown of organic residues and thus releasing some of all essential nutrients. Feed tests have improved greatly, higher calcium, phosphorus, magnesium, trace minerals and especially sulfur makes protein available. "Calcium, CEC has risen and calcium in forage test have increased almost double from 1 to 1.8-2%.

Robert Schmidtknecht

"All (soil) tests show an increase especially on heavier soils. CEC has also increased from 12-15 during this period. I had used high calcium lime prior to this but (was) not showing anywhere near this for results."

John Feuker

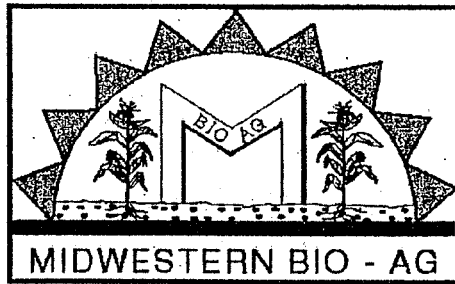
"A good release of nutrients on our clay soils."

Greg Schmidtknecht

"It gave us better weed control and also helped make better use of our nitrogen on the corn ground. A must product. We had high levels of all soil nutrients especially on our heavier ground. Higher levels of calcium, phosphorus, magnesium and especially sulfur."

Gordon Goss

"A very beneficial product for us." Soil tests "much improved even on our lighter soils." Feed tests "higher mineral readings with much better sulfur helping us cut back on our protein needs as well as minerals."



Bio-Cal[®] is *different* from all other liming materials

- Provides 150 lbs. of soluble Calcium per ton
- Supplies Calcium that is highly available to plants
- Buffers pH
- More cost effective than liquid calcium sources
- Also contains Sulfur and trace minerals
- Low Magnesium content, Magnesium : Calcium ratio 1: 5 - 1: 7

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Cover photography by Kerri Marshall-Edgerly

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by any means, without permission in writing from the publisher.

Printed in the United States.
First Printing.

Publisher's Cataloging-in-Publication

Zimmer, Gary F.

The biological farmer : a complete guide to the sustainable &
profitable biological system of farming / Gary F. Zimmer. — 1st ed.

p. cm.

Includes index.

Library of Congress Catalog Card Number: 99-76577

ISBN: 0-911311-62-9

1. Organic farming. 2. Alternative agriculture. 3. Sustainable agri-
culture. 4. Agricultural ecology. I. Title.

S605.5.Z56 2000

631.584

QBI99-1664

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LIMING & PH

Assuming that you have had your soil tested and have decided that you need to correct some serious imbalances, what do you do first? I can't make any blanket statements or recommendations, simply because soils are very different in different regions. In most soils of the eastern United States, the leaching from higher rainfall results in calcium levels being lower than the "ideal" range of 70 to 85 percent base saturation. In contrast, western U.S. soils often are adequate to high in calcium and are low in other elements. Obviously, your approach to soil balancing should be to raise the levels of low or deficient elements and to lower (or at least not raise) the elements that are in excess. It will probably take several years at least, and some soils may never, in practical terms, be able to be balanced to the "ideal" proportions. Still, moving them toward the ideal should improve crop performance. It may be that concentrating your efforts toward "row support," or providing well-balanced fertility in the row, and not trying to correct all of the soil is the most economical and practical method.

Since low calcium is so often the case in abused agricultural soils, we will begin with this element. In many ways, calcium is the key to building soil fertility. It improves soil structure, thus increasing aeration which is vital for good root growth and the beneficial forms of soil life. Higher levels of soil calcium increase availability of the other plant nutrients by such mechanisms as raising the soil's CEC and buffering capacity, increasing root growth and increasing microbial release of tied-up nutrients.

Calcium is a vital element in plant growth and health. It is necessary for strong cell walls, for cell division, for normal functioning of cellular membranes involved in nutrient uptake and energy release, and in helping prevent invasion of disease pathogens. By increasing root growth and regulating so many cell functions, adequate calcium also improves crop quality. But calcium cannot be transported from one part of a plant to another, so newly formed roots, stems and leaves need additional calcium from the soil. This means that a constant supply of available soil calcium is needed throughout the growing season. Overuse of nitrogen and/or many salt fertilizers leads to acidity or a tie-up of calcium. This can happen in soils that are supposed to have plenty of calcium. Research by Dr. Lloyd Fenn at Texas A&M's El Paso Agricultural Experiment Station found that plants may not get enough readily available calcium, even in high-calcium soils. By supplying a readily available form of calcium along with ammonium-bearing fertilizers, he had yield increases of 53 percent for dry land cotton, 60 percent for lettuce and 56 percent for peanuts, as well as increases in plant hardiness and disease resistance.

Because of the overwhelming importance of adequate calcium, when you are balancing soil and calcium is low, be sure to begin by adding calcium. But what kind of calcium? Most people think "lime" when you mention calcium, and farmers have been conditioned to think of liming as a remedy for soil acidity and use it to correct pH. The subjects of calcium, lime and pH can be confusing and have been used carelessly in the literature on the subject, so let's define and explain them.

What is pH?

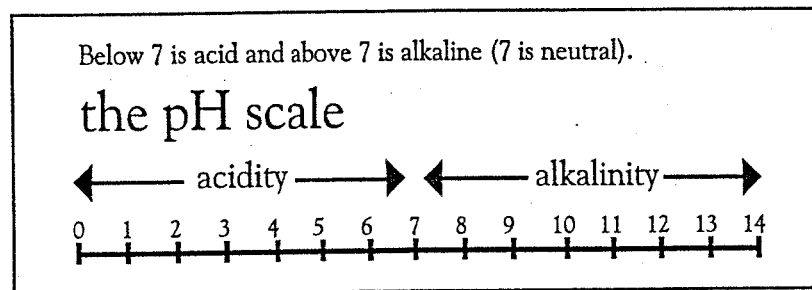
The term pH is a chemical abbreviation for the concentration of hydrogen ions, which cause some of the acidity in soil. Technically, pH is the negative logarithm of the hydrogen ion concentration. Therefore, every whole number change in this logarithmic scale is a change of 10 times the hydrogen ion concentration. For example, a pH of 5.8 is ten times more acid than 6.8, and 4.8 is 100 times more acid than 6.8.

Hydrogen ions (H^+) only cause soil acidity as measured by a standard pH test when they are in water solution. This is called *active acidity*. Most hydrogen ions in typical soil are loosely attached (adsorbed) to soil particles, along with other positively charged ions (cations), such as calcium, magnesium, potassium, sodium and aluminum. The soil particles carry many negative electrical charges, which are what attract the positively charged cations (unlike charges attract, and like charges repel). When hydrogen ions are attached to particles, they are called potential acidity, and do not contribute to soil pH (as it is usually measured) at that time,

but they are present to contribute to acidity if conditions change. If soil acidity is neutralized by liming materials, both active and potential acidity are neutralized. Aluminum ions can also contribute to soil acidity at acid pHs, but pH only measures hydrogen ions, not aluminum.

Many people believe that soil pH is fairly constant, but the pH can vary widely from one specific place to another (such as in the row versus between rows) or from one month to another. The pH immediately next to a root can be one or two points lower (more acid) than the surrounding soil. Fertilizer applications can cause large changes in pH, both short-term and long-term. High ammonia (or high ammonium-containing fertilizer) use and/or high salt fertilizer use tend to lower soil pH.

The pH measures just the hydrogen ions in solution, but there is more to the story. A water solution contains not only hydrogen ions (H^+), but also hydroxyl ions (OH^-), which cause alkalinity. There is a balance between the two. When there are more hydrogen ions, there are fewer hydroxyl ions and vice versa. Scientists use a pH scale to measure the total range of acidity and alkalinity. The pH scale ranges from 0 (most acid) to 14 (most alkaline), with neutral (pH 7) being midway between:



The pH of some common materials includes: lemon juice = 2, vinegar = 2.5, black coffee = 5, pure water = 7, sodium bicarbonate solution = 8.2, ammonia water = 11. In pure water, there is an equal number of hydrogen and hydroxyl ions, so the pH is 7, or neutral. If there is something else in the water which either uses up or adds hydrogen or hydroxyl ions, the solution becomes acid or alkaline.

In the soil, there is a complex mixture of components which can affect pH including clay, humus, organic molecules, soluble inorganic salts and carbon dioxide. The soluble salts include carbonates, bicarbonates, nitrates, sulfates and chlorides of calcium, magnesium, potassium, sodium and other minor elements.

A *salt* is made up of two parts, or ions, loosely held together. One ion is positively charged (the cation) and the other is negatively charged (the anion). For example, calcium carbonate is made up of calcium ions and

carbonate ions, $\text{Ca}^+ + \text{CO}_3^-$. Placed in water, some or all of the ions of a salt will separate (dissociate) and become free to recombine with some other ion of opposite charge.

A fertile soil has most of the negative charges on its colloidal clay and humus particles filled with cations which are plant nutrients (calcium, magnesium, potassium, ammonium). As roots absorb nutrient cations and exchange them for hydrogen ions (called base exchange; see Chapter 5), more and more hydrogen ions accumulate, and the soil becomes more acid; that is, the pH drops. Below pH 5, larger numbers of aluminum ions are released from clay particles, also contributing to soil acidity. In general, an acid soil is a low fertility soil. But there are other aspects to soil pH.

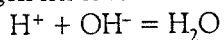
Actually, the pH of the soil has little direct effect on plant growth. Experiments have shown that if a plant's roots have access to adequate nutrients and there is no toxicity, moderate to strong acidity or alkalinity causes no problems. But too low or too high pH can adversely affect plant growth in other ways. The availability of the various plant nutrients varies at different pHs, some being less available at low pH (acid) and others less available at high pH (alkaline). Elements such as aluminum, manganese and copper are toxic to plants in too large amounts, so at extreme pHs, plants can suffer from a deficiency of a needed element or from a toxicity of another. (Refer to element availability chart on following page.)

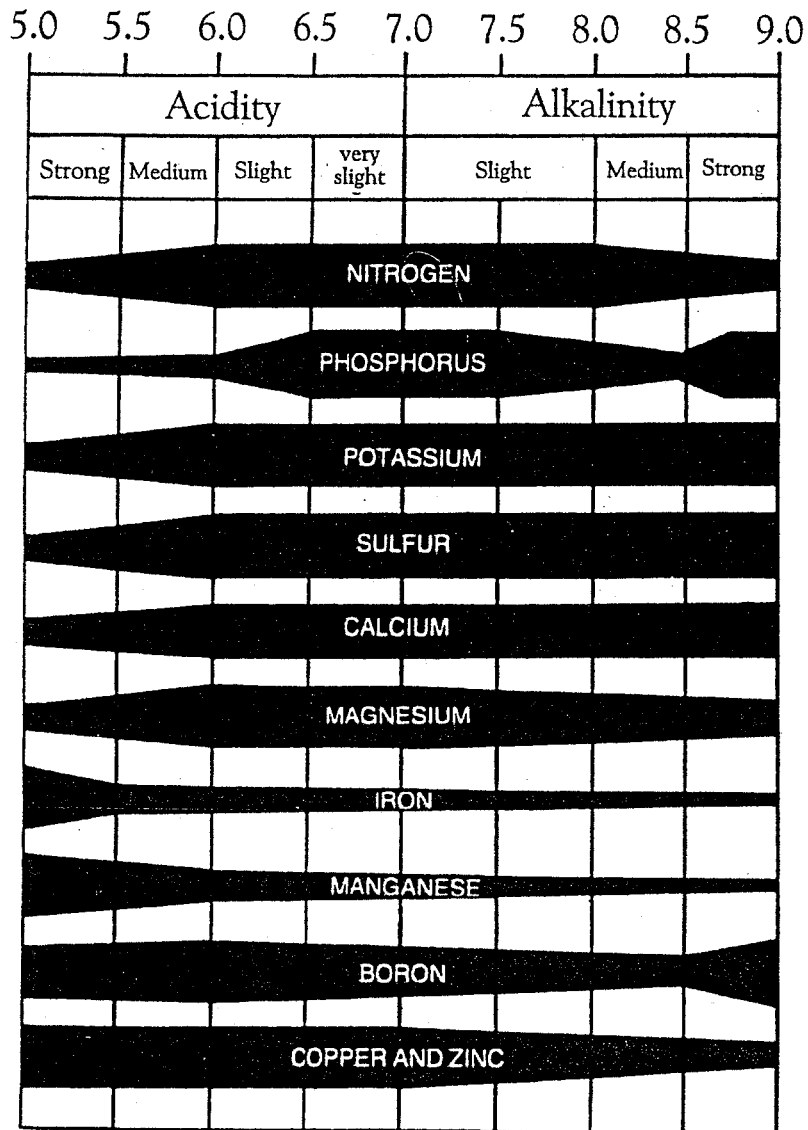
Soil pH also affects the activity of beneficial soil microbes. Bacteria and actinomycetes prefer alkaline pHs, while fungi do best in acid conditions. Plants grow better when beneficial organisms are abundant in the soils (see Chapter 5), so a soil pH that is not too acid and not very alkaline is a good compromise.

For best organism activity and best availability of most nutrients, the soil pH range from about 6.2 to 6.8 is generally recommended as "ideal" for most soils and most crops. However, highly weathered tropical soils which are high in aluminum and iron are naturally very acidic and cannot be raised to over pH 5.5 or 6.0 without degrading soil structure and causing serious imbalances and toxicity from trace elements. Some soils in the southeastern United States are of this type.

Neutralization. Since excessive acidity generally is not good for plant growth and does not allow adequate fertility, farmers will want to eliminate the acidity or neutralize the hydrogen ions or raise the pH ("sweeten" the soil). This is accomplished by adding a so-called liming material to the soil, something that tends to neutralize acidity.

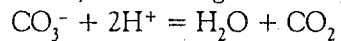
Acidity (hydrogen ions) is neutralized, for example, when a hydroxyl ion combines with a hydrogen ion to form water:





Availability of Elements to Plants at Different pH Levels for Typical Soils

The most common liming material is limestone, typically calcium carbonate (CaCO_3). In the soil, a little of the limestone dissolves in the soil water, releasing the two ions, Ca^{2+} and CO_3^{2-} . The carbonate ion combines with two hydrogen ions, neutralizing the acidity:



In this case, both water and carbon dioxide are by-products. The calcium ion that is left over can then become attached to a soil particle, helping to restore the soil's supply of plant nutrients.

Now, perhaps you can realize a couple of important facts. First, it is not the calcium that neutralizes soil acidity; it is the other ion that is attached to the calcium (in this case the carbonate ion in the limestone). Magnesium carbonate (a part of some limestones called dolomite or dolomitic limestones) is also an effective neutralizer of soil acidity — and it contains no calcium. Also, some calcium-containing materials do not raise soil pH; they might even make the soil more acid. An example is gypsum, calcium sulfate. The sulfate ion could combine with hydrogen to form sulfuric acid, H_2SO_4 .

So, once again, calcium *does not* neutralize acidity, but since most commonly used liming materials contain calcium, the idea that calcium neutralizes acidity has become widespread.

Carbonate limes, either calcium carbonate or calcium magnesium carbonate, should only be used if the pH is low. Trying to change the soil Ca:Mg ratio at pH 7 or above using lime is not effective, or is extremely slow. These carbonate limes are low in solubility and soil acidity improves their solubility. So if the soil pH is neutral and you still need to add calcium, the use of gypsum and/or hydrated lime work better. Carbonate limes have two or fewer pounds of soluble calcium per ton, gypsum has 25 pounds and BioCal or hydrated lime with sulfur present have 150 pounds of soluble calcium per ton.

Another thing to realize is that the most important result of liming soil is not neutralizing the acidity, but replacing the cation nutrients that have been depleted by plants. Of these cations, the most important is calcium, since it normally occupies about 70 to 85 percent of the negatively charged sites of soil particles (in fertile soils), with magnesium about 12 to 18 percent and potassium 3 to 5 percent.

Why lime?

The subject of liming soils is complicated by the effect of pH on plant nutrient availability and soil life and by the particular cations that come along with the neutralizing ions. Different crops are said to "prefer" a certain soil pH. For example, alfalfa "prefers" pHs from 6.5 to 7.5, corn and wheat 6.0 to 7.0, but rye likes 5.5 to 6.5. Is it really the pH that these crops "prefer," or is it that some crops, like legumes, need higher levels of calcium than grass crops? Since soils are usually limed with calcium-supplying materials, high-pH soils usually provide more of the needed calcium. You still may need to supplement with a soluble source.

Dr. William A. Albrecht showed the truth of this in a paper entitled "Soil Acidity as Calcium (Fertility) Deficiency," published in 1952 (*Research Bulletin No. 513*, University of Missouri Experiment Station; G.E. Smith co-author). He grew soybeans and spinach in highly acidic soils (pH 4.0, 4.5 and 5.0), but he supplied them with a balance of nutrients including plenty of calcium. Other plants were grown in similar soils, but with less and less calcium, or none at all. The plants grew perfectly well as long as there was sufficient calcium present. The "low-calcium" and "no-calcium" plants were severely stunted. Growth was good when the base saturation of calcium was at least 60 percent, although much better growth resulted above 75 percent calcium. Soybean nitrogen-fixing nodules only developed normally when there was adequate calcium (in fact, Dr. Albrecht found that nodules would not develop in pH 7.0 soil if there was not enough calcium). The test plants took up not only more calcium in high-calcium soil, but more of all nutrients; thus their nutritional value as food was much higher.

Research

Most scientific tests that determine the effects of soil nutrients on crops usually only measure yield, or *quantity*. Rarely are such things as crop diseases, pests, nutritional value or storability measured — things we usually call *quality*. Rarely does a scientific study last long enough to follow the long-term effects of applied fertilizers or liming materials. Many studies are conducted with plants in pots in a greenhouse, and results may or may not apply to field conditions. Sometimes soil is sterilized beforehand, while in real life field soil is populated by many organisms, and certain ones are essential to healthy, high-yielding crops. Agricultural scientists almost never follow through and feed their test crops to animals to see their real nutritional value. Nutritionists do that sort of thing, and they may not care how a crop was fertilized or whether the soil had beneficial organisms.

Yet such total, long-range, full-circle testing is not that difficult or expensive. Decades ago, Dr. William A. Albrecht found that small animals such as rabbits and guinea pigs can adequately substitute for livestock in testing (bio-assaying) crop quality. Dr. Albrecht and his associates found that alfalfa and clover fertilized with plenty of calcium (lime) resulted in more efficient weight gain (more gain on less feed) and better quality wool when fed to sheep, rabbits and guinea pigs. Similar research in Wisconsin using alfalfa and Ladino clover fed to guinea pigs found that moderate, balanced soil fertilization produced nutritionally superior feed (best weight gain), while heavy fertilization decreased feed value.

The amounts of calcium that soil scientists used to think were sufficient are in some cases not enough for quality crops or even average growth. Part of the reason is that calcium does not readily move from one part of a plant to another. It cannot be transferred from older leaves to younger or from leaves to developing grain or fruit. A continuous supply of calcium is needed for peak yield and quality. Measuring soil calcium at the beginning of the growing season or an experiment does not assure that there will be enough throughout the life of the plant. Soil aeration and organisms are important. Suffocated roots cannot grow out into the soil and absorb more calcium, and adequate calcium is needed for root growth. Too high levels of other cations — magnesium and potassium — will decrease the amount of calcium a plant will take up. Calcium *can* be a limiting factor in crop production.

What About Ratios?

A subject that causes some controversy with regard to liming materials is the importance of the relative amounts of soil nutrients, usually expressed as ratios. Based on numerous studies, some soil scientists have written that the ratio of calcium to magnesium is not important (within limits) and that as long as there is enough calcium and magnesium to replace what the crop removes, there are no problems. Further, they say that if dolomitic lime (which contains both calcium and magnesium) is cheaper than calcitic lime (high-calcium lime, calcium carbonate), then it is better to use dolomite. Specifically, they say that various Ca:Mg ratios ranging from about 0.5:1 (high magnesium) to more than 30:1 (high calcium) do not affect the yield of crops. That may be true, but as we mentioned earlier, what about quality, especially food value? And what about possible effects on soil structure? And humus? And soil life? These trials were done using what they call optimum fertilization. What would the results be if you cut the fertilizer in half?

Do ratios of soil nutrients matter? We have covered the fact that plants need some nutrients in relatively large amounts, others in lesser amounts and the trace elements in very small amounts. Obviously, the relative amounts of different elements *do* matter. In fact, some of them, especially some of the trace elements are toxic in too large amounts. A balance is important. But how critical are exact ratios? And who decides which balance is best?

According to a standard soils textbook, the typical proportions of cations in clay soils are 75 to 85 percent calcium (base saturation), 12 to 18 percent magnesium and 1 to 5 percent potassium (L.M. Thompson & E.R. Troeh, *Soils and Soil Fertility*, 4th ed., 1978, p. 167). If we calculate the

Ca:Mg ratios, they would range from about 4:1 to 7:1, with much more calcium than magnesium. But plant absorption of these two elements averages about 1.6:1, with different crop species requiring somewhat different ratios (using textbook figures, alfalfa uses them in a 5.25:1 ratio, while corn uses nearly equal amounts of calcium and magnesium).

If you were to grow only one kind of crop, you could "fine-tune" your soil to that crop's needs, but most growers use a crop rotation of some kind, usually including a legume crop. It makes sense to fertilize soil for the most valuable crop and to rotate crops so that the preceding crop supplies what the next one needs. Usually the legumes in a rotation are high-value crops, perhaps alfalfa, soybeans, or other beans or peas. Legumes need larger amounts of calcium than magnesium. Calcium is important in many cellular functions, and no matter what the crop, higher calcium improves root growth, disease resistance and crop quality. Calcium improves soil structure and stimulates beneficial soil organisms. For those reasons, I like to see calcium-to-magnesium ratios of at least 5:1, or higher.

Of course, plants do need magnesium, too. It is essential for protein synthesis, chlorophyll production and as an activator of many cell enzymes. Some soils are definitely short of magnesium, especially leached and sandy soils with a low CEC.

There is an interaction between calcium and magnesium — and potassium as well. High soil potassium decreases the plant's uptake of both calcium and magnesium. Low magnesium and calcium, and high potassium in feeds leads to livestock health problems, such as grass tetany symptoms (downer syndrome, displaced abomasum, to mention two). High soil magnesium, as usually occurs in areas with dolomite bedrock, can lead to lower quality legume crops.

Some scientists worry that excessive use of high-calcium lime will result in too low magnesium levels in crops, which certainly can happen. That is why we like to strive toward a certain balance and not overdo a good thing.

Liming Materials

Commonly used liming materials include:

1. *High-calcium lime* (calcium carbonate, calcitic limestone, calcite, aragonite, CaCO_3) — with 32 to 40 percent calcium and less than three percent magnesium. Has fairly low solubility (slow acting); best incorporated into upper soil.

2. *Dolomitic lime* (calcium magnesium carbonate, dolomite, $\text{CaCO}_3 \cdot \text{MgCO}_3$) — variable, with about 22 percent calcium and eight to

20 percent magnesium. Low solubility; best incorporated into upper soil. Not always a good plant source of calcium.

3. *Marl* (calcium carbonate plus impurities) — variable percent of elements; an impure form of high-calcium lime. Other high-calcium materials include oyster shell, chalk, paper mill sludge, sugar-beet waste, and water treatment by-product. These have limited usage, and some may have too high levels of toxic heavy metals.

4. *Liquid lime* (fluid lime; a suspension of very fine particles of any liming material) — variable sources and calcium:magnesium contents. Good plant availability, but expensive because of water content.

5. *Quicklime* (calcium oxide, burned lime, unslaked lime, CaO) — 60 to 71 percent calcium. Very caustic and difficult to handle; highly reactive in soil; seldom used.

6. *Slaked lime* (calcium hydroxide, hydrated lime, CaOH) — 45 to 55 percent calcium. Caustic and difficult to handle; highly reactive in soil.

7. *Kiln dust* (calcium oxide and calcium hydroxide plus other elements) — 28 to 36 percent calcium, up to 5 percent potassium, 2 to 4 percent sulfur. A by-product of cement or burnt lime manufacture. Good solubility and plant availability; can be surface applied; difficult to handle.

8. *Basic slag*, blast furnace slag (variable composition; mixtures of calcium silicate, calcium oxide and calcium hydroxide; may contain magnesium and phosphorus and other elements) — about 29 to 32 percent calcium. A by-product of steel manufacture.

9. *Fly ash* (variable composition; mixture of calcium oxide, calcium hydroxide and calcium carbonate, plus sulfur, boron and molybdenum). Fine particles; difficult to spread.

The speed and effectiveness of these liming materials depends not only on their composition and solubility, but also on the size of their particles. Materials with lower solubilities, such as limestones, should be finely ground or applied far ahead of their desired action. In fact, dolomitic lime is such a hard stone that it can take surface-applied dolomite 10 to 13 years to neutralize acidity two inches below the surface. Consultants recommend applying and incorporating it about 18 months ahead of time. High-calcium lime acts somewhat faster at first, while the very fine particle size of such materials as liquid lime, kiln dust and fly ash give fast, same-year action.

For soils that are low in magnesium, most people recommend dolomitic lime, but again, its slow action is a disadvantage. Better, quickly available magnesium sources include sul-po-mag (potassium magnesium sulfate, sulfate of potash-magnesia, or K-mag) and magnesium sulfate (epsom salts); however, neither of these materials is a liming material (they do not

neutralize acid). Some research has found that dolomite does not supply enough calcium for some crops (corn, potatoes and other vegetables).

If you want a calcium-supplying material but do not want to raise the soil's pH, as on alkaline soils, then an excellent material to use is gypsum (calcium sulfate). It does not neutralize acid and contains 22 to 23 percent calcium, plus 18 percent sulfur, a valuable nutrient. Another excellent source is kiln dust with sulfur. It is higher in solubility than gypsum, and because of the fine grind, can be surface-applied. It gives excellent results the first year. It works more like a fertilizer than a liming material.

The following table gives the results of a five-year comparison of high-calcium lime, gypsum and BioCal (a blended, formulated kiln dust product from Midwestern Bio-Ag). They were the only soil correctives on the fields, but a balanced crop fertilizer was used. The field has been on a corn/soybean rotation with rye following soybeans and the corn interseeded with rye grass and clover. No herbicides or insecticides were used. Yields have been good to excellent. Corn yields ranged from 140 to 240 bushels per acre. Soybeans have been in the 50 to 65 bushels per acre range. The only tillage besides cultivation is a shallow incorporation of residues with a Howard Rotavator.

1991 field	High-cal lime 1 ton/acre		Gypsum 1,000 lbs/acre		BioCal 1,000 lbs/acre		
	1995	1997	1995	1997	1995	1997	
Average:							
O.M.	2.1 L	1.9	1.9	2.8	2.2	2.5	2.3
ppm P1	89 VH	75 VH	87 VH	82 VH	75 VH	127 VH	105 VH
ppm P2	141 VH	114 VH	153 VH	150 VH	131 VH	217 VH	153 VH
% base saturation:							
K	5.2 VH	4.6 VH	4.5 VH	3.8 H	3.9 H	5.1 VH	4.5
VH							
Mg	30.4 VH	33.7 VH	31.7 VH	28.8 VH	28.9 VH	29.4 VH	27.6 H
Ca	64.4 M	61.7 M	63.8 M	67.4 M	67.2 M	65.5 M	67.9 M
pH	7.3	7.0	7.3	7.3	7.2	6.9	7.4
ppm:							
S	21 H	10 L	28 H	16 M	25 H	12 L	29 H
Zn	2.0 M	2.8 M	3.1 M	4.4 H	4.3 H	4.2 H	4.1 H
Mn	16 H	17 H	17 H	17 H	13 M	16 H	13 M
Fe	19 H	51 VH	34 VH	47 VH	33 VH	43 VH	35 VH
Cu	0.6 L	1.0 M	1.2 M	1.0 M	1.1 M	1.3 H	1.3 H
B	1.2 M	0.7 L	1.0 L	0.7 L	1.2 M	1.0 M	1.4 M

(soil tested by Midwest Lab, Omaha)

L = low, M = medium, H = high, VH = very high

Comments:

First of all, the soil test numbers are guides and give trends. This field was a high P/K testing field when we started. CECs range from 10 to 12, and it is a well-drained silt/loam. No matter which lab you send the samples to, they should come back high in P and K. The numbers may be different, but results the same. The soils in Wisconsin are high in magnesium and medium to low in calcium. Except for some trace elements, the only soil correction would be adding more calcium and less magnesium. Because the pH is near or above neutral, lime would not be the preferred source of calcium. Gypsum and/or BioCal fit better. They provide a more soluble calcium plus sulfur, which should also help to reduce magnesium if drainage is good.

For whatever reason, the organic matter levels increased on the gypsum and BioCal fields, but not on the lime field. As for phosphorus, the levels are still in the VH range, but the BioCal numbers trend higher, with no added phosphorus. Potassium levels have held well. There appears to be a trend toward lower K levels in the gypsum plot. The row fertilizers for corn and soybeans are:

	Corn row fertilizer 350 pounds/acre	Soybean row fertilizer 200 pounds/acre
N	15%	12%
P ₂ O ₅	8%	9%
K ₂ O	2%	3%
Ca	3%	8%
S	16%	13%
B	0.12%	0.15%
Cu	0.12%	0.15%
Mn	0.4%	0.45%
Zn	0.5%	0.6%

Ingredients of Row Fertilizers:

A blend of Hartland ammonium sulfate, MAP (monoammonium phosphate), sulfate of potash, North Carolina rock phosphate, Idaho soft rock phosphate, calcium sulfate, granulated calcitic lime, sea kelp, fish meal, molasses, diatomaceous earth, manganese sulfate, copper sulfate, calcium borate, zinc sulfate. This is a blended, homogenized mix with a final pH of 5.5.

Note that because soil K levels are very high, we use a row fertilizer that is low in K. These soils have maintained K levels with no corrective, crop or maintenance K. Soil testing is a way of monitoring what is happening. If K levels were dropping, we would change row fertilizer and add more, or bulk-spread a soil corrective. We would also question our tillage, green manure crop program and evaluate earthworms and biological activity. This program should sustain our soil fertility or else we will be growing crops by robbing from the soil's reserve, and our future would look bleak. Remember, we test to give direction and clues, and to monitor our program.

Now look at magnesium:calcium ratios. Adding the high-calcium lime doesn't seem to change anything. We believe this is due to its low solubility. If the soils were acid, it should work better. Both gypsum and BioCal are improving these ratios. A recent test has the BioCal field at 25 percent Mg and calcium over 70 percent. What about quality and yields? Quality is hard to measure without feeding trials. The yields have been slightly higher on the BioCal and gypsum plots. The future is exciting as these soils improve; our yields can improve or we can get the same yields with lower input. As for quality, in the feeding chapter, I will show what is happening with this type of fertilizer program. How much value do we put on the increase in OM?

Now look at trace elements. We have not bulk spread any correctives. As for sulfur, note from the row fertilizer that we are getting 40 to 50 pounds per acre, plus on the gypsum plot, another 170 pounds (gypsum contains 17 percent sulfur), and on the BioCal plot, an additional 60 pounds. This is not reflected in the soil test. Sulfur is an anion and will leach out provided we have no hardpan. The numbers on the test jump all over based on rainfall and time of application. The theory is that the extra sulfur binds with magnesium, forming epsom salts (magnesium sulfate) and leaches out. It appears that this is happening.

Zinc, copper and boron levels tend to be improved in the gypsum and BioCal plots over the lime plot. All plots get the same application rate. This could be due to the higher organic matter levels, better biological activity, improved nutrient cycling or any other logical reason you could come up with.

As for manganese and iron, these levels move based on tillage (more oxidation), use of harsh fertilizers and biological activity. Manganese soil tests give you clues to the activity at the time of testing. If the pHs are neutral or above, and you have high levels of manganese, the biological activity at that moment is good. We like a ratio of 1:1 for Mn:Fe. This

means oxidation and biological activity are in balance as they should be. Again, these are more clues as to what could be happening in the soil.



Gar-Ville Chief Fein Ex 91

Batch

Several more Questionnaires
Will Perhaps have Several more
within The next few weeks.

If I can be of any further
help To speed up The process let
me know.

We hope to see the Bio-Cal
approved for The Organics next year

Thanks

Bob

A handwritten flourish consisting of a wavy line that starts under the name "Bob" and extends downwards and to the right.

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 1 yr

3) Which crops? Corn X Soybeans _____
Alfalfa X Other X Small

4) At what application rate? 500 #

5) Did you see a difference in the soil tests before and after? Didn't Test

6) Did you take feed tests on the crops? NO

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes
COWS consumed much less mineral

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms yes C) Looser soil _____

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 11-3-00

Signature: Paul Eicher - Amish

X CROPS Looked Better, deeper green color -
corn had much larger ears.

M.B.A. BIO-CAL Questionnaire1) Have you used Bio-Cal? Yes No 2) How many years have you used Bio-Cal? 103) Which crops? Corn Soybeans
Alfalfa Other Pasture4) At what application rate? 750# Per acre5) Did you see a difference in the soil tests before and after? Better (cation Exchange Capacity - Calcium #s are much better.6) Did you take feed tests on the crops? Yes - I have the local coop take samples to compare to Bio-ABS & continually comes back as one of the highest he has seen.7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes
Forage Calcium Levels have continually risen.8) What benefits have you seen from Bio-Cal use on your farm? A) More energy B) More earth worms C) Looser soil 9a) Have you ever experienced any adverse effect with using Bio-Cal? b) If so what effects? Date: 11/1/2000Signature: David Clinton

Bio-Cal has been an economical, healthy & very beneficial. One product I can use & know it's going work for me.

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8

3) Which crops? Corn X Soybeans _____
Alfalfa X Other X

4) At what application rate? 500 - 1000 #

5) Did you see a difference in the soil tests before and after? YES

6) Did you take feed tests on the crops? YES

7) Did you see any significant difference in the calcium levels after using Bio-Cal? YES
MUCH HIGHER CAL + DHS

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil X

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 11-2-00

Signature: [Handwritten Signature]

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 10 YRS

3) Which crops? Corn X Soybeans X
Alfalfa X Other _____

4) At what application rate? 300 - 1000

5) Did you see a difference in the soil tests before and after? soil and trace minerals higher

6) Did you take feed tests on the crops? yes, higher calcium plus magnesium trace minerals and sulfur better protein available

7) Did you see any significant difference in the calcium levels after using Bio-Cal? calcium increased in feed

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil X

9a) Have you ever experienced any adverse effect with using Bio-Cal? none

b) If so what effects? _____

Date: 11/2/00

Signature: Daniel Schaal

Better alf stands

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 7

3) Which crops? Corn _____ Soybeans _____

Alfalfa X Other Small grains

4) At what application rate? 500-1000

5) Did you see a difference in the soil tests before and after? YES. The Soluble Calcium helped release other elements feed up in my heavier soils.

6) Did you take feed tests on the crops? yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? yes had higher mineral readings on my forage test.

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy yes

B) More earth worms yes

C) Looser soil yes

9a) Have you ever experienced any adverse effect with using Bio-Cal? No

b) If so what effects? _____

Date: 11-3-01

Signature: Bill Clark

* A very good product.

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8

3) Which crops? Corn ✓ Soybeans _____
Alfalfa ✓ Other Barley

4) At what application rate? 500-1000 #/A

5) Did you see a difference in the soil tests before and after? Yes

6) Did you take feed tests on the crops? yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal?
yes - soil became looser / weed pressure decreased / yields increased

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy ✓
B) More earth worms ✓ C) Looser soil ✓

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) I don't believe we will see a fall back of our soil nutrients and a decrease in our forage tests.

Date: 10/30/00

Signature: [Handwritten Signature]

** We used Bio-Cal long before we went Organic. We feel that long term, if we don't have Bio-Cal for the reasons stated above, we may have to quit being organic as we can use it again.*

Bob & Lorraine Schmitt
Nov 01 00 07:44

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8

3) Which crops? Corn ✓ Soybeans _____
Alfalfa ✓ Other _____

4) At what application rate? 500#/1000# PER ACRE

5) Did you see a difference in the soil tests before and after? YES
MUCH IMPROVED MINERAL
AVAILABLE IN FORAGES

6) Did you take feed tests on the crops? YES

7) Did you see any significant difference in the calcium levels after using Bio-Cal? _____
DIFFERENT INCREASES IN ALL
FORAGES

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy ✓
B) More earth worms ✓ C) Looser soil ✓

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 10-30-00

Signature: Charles Wolf

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 7

3) Which crops? Corn _____ Soybeans _____
Alfalfa X Other Small Grains

4) At what application rate? 500 1000

5) Did you see a difference in the soil tests before and after? yes had increases of all nutrients

6) Did you take feed tests on the crops? yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? yes, higher Calcium, plus Magnesium with a very good increase in Sulfur

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil X

9a) Have you ever experienced any adverse effect with using Bio-Cal? None

b) If so what effects? _____

Date: 10-30-00

Signature: Tom Basmerwick

Better yield, Better quality - longer lasting stands

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 9

3) Which crops? Corn X Soybeans _____
Alfalfa X Other Small Grains

4) At what application rate? 500-1000

5) Did you see a difference in the soil tests before and after? Yes, had increase of all nutrients especially on our higher fertility soils.

6) Did you take feed tests on the crops? Yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes high test minerals better energy, even when made better

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy Yes

B) More earth worms Yes C) Looser soil Yes

9a) Have you ever experienced any adverse effect with using Bio-Cal? Heck No

b) If so what affects? _____

Date: 10-30-00

Signature: Gregory J. Netrich

Others - Better yields, Higher Quality, Higher Trace
↓ minerals - Better utilization of Protein

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8

3) Which crops? Corn X Soybeans _____
Alfalfa X Other Small Grains

4) At what application rate? 500-1000 # Acre

5) Did you see a difference in the soil tests before and after? Yes
Higher trace minerals, higher calcium
levels, higher organic matter levels

6) Did you take feed tests on the crops? yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes
higher & much better testing forages

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil X

9a) Have you ever experienced any adverse effect with using Bio-Cal? No

b) If so what effects? _____

Date: Oct 30, 2000

Signature: Dennis E. Hethel

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes No

2) How many years have you used Bio-Cal? 4

3) Which crops? Corn Soybeans
Alfalfa Other Pasture

4) At what application rate? 250 750 #/Ac.

5) Did you see a difference in the soil tests before and after? didn't test
but forage certainly Fed better, and ground
was looser

6) Did you take feed tests on the crops? yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Better
Yield, Better quality forage, longer lasting stand, had
2% Calcium haylage

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy yes

B) More earth worms yes C) Looser soil yes

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 10-27-08

Signature: Anthony B. Beyer

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes 1 No _____

2) How many years have you used Bio-Cal? 4

3) Which crops? Corn X Soybeans X
Alfalfa X Other _____

4) At what application rate? 500

5) Did you see a difference in the soil tests before and after? yes, Calcium was some higher & we seemed to have a release of all other nutrients especially in our heavier soils (clays)

6) Did you take feed tests on the crops? yes, higher Calcium - & other nutrients sulfur etc

7) Did you see any significant difference in the calcium levels after using Bio-Cal? yes, from 1.2% up to 1.9%

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy NO?

B) More earth worms yes C) Looser soil yes

8a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 11/21/00

Signature: Frank Perry

B

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 4

3) Which crops? Corn _____ Soybeans X
Alfalfa X Other Pasture

4) At what application rate? 750 #

5) Did you see a difference in the soil tests before and after? YES Better yield
better quality, longer lasting stands, did not test soil

6) Did you take feed tests on the crops? YES

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Calcium
and all nutrients ran higher on fields spread could
visually see difference in fields darker color & taller

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy YES

B) More earth worms YES C) Looser soil YES

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 10-27-00

Signature: John T. Lison

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8 yrs

3) Which crops? Corn X Soybeans NO
Alfalfa X Other Grains

4) At what application rate? 500-1200 #

5) Did you see a difference in the soil tests before and after? yes - all test show higher available nutrients

6) Did you take feed tests on the crops? yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? yes Calcium had increase significantly. have many test that are now testing 1.7 & 2 Calcium

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy yes

B) More earth worms yes C) Looser soil yes

9a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 10/27/00

Signature: Bill Thomas

Also= Better yield, Dark color Alfalfa, Solid stem Alfalfa
higher quality- stands last longer

10-25-00 20:53

10-

P.01

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8 YRS

3) Which crops? Corn X Soybeans _____
Alfalfa X Other Pasture

4) At what application rate? 500-TO 1,000 #

5) Did you see a difference in the soil tests before and after? Yes - The soil Trace minerals show higher because of the breakdown organic residues and thus releasing some of all essential Nutrients

6) Did you take feed tests on the crops? Feed Test have Improved greatly - higher calcium, phos, magnesium, Trace minerals & especially Sulfur makes protein available as true protein

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes, Calcium C.E.C. has risen and Calcium in forage Test have increased almost double from 1.7 to 1.8 to 2.0

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil X

9a) Have you ever experienced any adverse effect with using Bio-Cal? None

b) If so what effects? _____

Date: 10-28-2000

Signature: Patrick A. Berg

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8

3) Which crops? Corn X Soybeans _____
Alfalfa X Other X

4) At what application rate? 500-1000 #

5) Did you see a difference in the soil tests before and after? Yes all test
Show an increase especially on heavier soil C.E.C
has also increased from 12-15 during this period. I had used
high Calcium lime prior to this, but not showing any where near this
6) Did you take feed tests on the crops? Yes for results

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes nutrients
have all been running higher with a much better
balance, helping keep cattle much healthier.

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X
B) More earth worms X much more C) Looser soil X holds water much
better

8a) Have you ever experienced any adverse effect with using Bio-Cal? None

b) If so what effects? _____

Date: 10-29-00 Signature: Robert Schmiedeknecht

Also * Crops have been of better quality, better yield with less inputs, and the alfalfa & pasture stands last much longer.

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 3

3) Which crops? Corn X Soybeans NO
Alfalfa X Other Sc

4) At what application rate? 500^{lb}

5) Did you see a difference in the soil tests before and after? Yes, # good
release of nutrients on our clay soils.
Very pleased with results

6) Did you take feed tests on the crops? Yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes
higher Calcium Phos & Magnesium

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil yes

8a) Have you ever experienced any adverse effect with using Bio-Cal? NO

b) If so what effects? _____

Date: 10-30-00

Signature: John Feuber

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 6

3) Which crops? Corn X Soybeans _____
Alfalfa X Other Small grains

4) At what application rate? 500-750 #

5) Did you see a difference in the soil tests before and after? Yes, we had high levels of all soil nutrients, especially on our heavier ground

6) Did you take feed tests on the crops? Yes

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes higher levels of Calcium, Phos, Magnesium & especially Sulfur

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy yes

B) More earth worms yes

C) Looser soil yes

9a) Have you ever experienced any adverse effect with using Bio-Cal? No

b) If so what effects? _____

Date: 10-31-00

Signature: Ray Schmidt

* It gave us better weed control and also helped make better use of our Nitrogen on the corn ground. A must product for Organics

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes X No _____

2) How many years have you used Bio-Cal? 8

3) Which crops? Corn X Soybeans _____
Alfalfa X Other Small Grains

4) At what application rate? 500-1000^{lb} / Acre

5) Did you see a difference in the soil tests before and after? YES, much Improved
even on our lighter soils

6) Did you take feed tests on the crops? YES

7) Did you see any significant difference in the calcium levels after using Bio-Cal? YES
higher mineral readings. With much better Sulfur
helping us cut back on our protein needs as well as minerals

8) What benefits have you seen from Bio-Cal use on your farm? A) More energy X

B) More earth worms X C) Looser soil X

9a) Have you ever experienced any adverse effect with using Bio-Cal? No

b) If so what effects? _____

Date: 10-31-00

Signature: Gordon Ross

* A very beneficial product for us since we are organic.