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June 20, 2001

National Organics Standards Board
c/o Robert Pooler
Agricultural Marketing Specialist
USDA/AMS/TM/NOP
Room 2510-So
Ag Stop 0268
P.O. Box 96456
Washington, D.C. 20090-6456

RE: Bio-Cal Calcium Complex
Calcium Oxide
Calcium Hydroxide

Dear Sir:

In a letter dated November 20, 2000 Meeker Farms, Inc. submitted a petition to allow the use of Bio-Cal Calcium Complex as an approved synthetic material for use in crop production. We recognized that approval of a formulated product was not envisioned in the NOSB petition rules, but we proceeded in this manner anyway because we felt that the Bio-Cal product had unique characteristics and was well proven in its use on many organic farms in the Midwest. The individual components such as calcium oxide and calcium hydroxide have proven to be beneficial and healthful when included in a calcium complex such as Bio-Cal. The impact of pure or concentrated calcium oxide is considerably different than a calcium complex containing calcium oxide. Hydrated lime has been approved for restricted use on crops as a foliar for disease control, primarily as a component of Bordeaux mix. We believe that hydrated lime contains calcium hydroxide and some calcium oxide that was not fully hydrated when calcium hydroxide was formed. In this respect the hydrated lime in Bordeaux mix has some similarities to the hydrated lime in Bio-Cal. The Bio-Cal product is less aggressive than Bordeaux mix because it has other calcium compounds that buffer the calcium oxide and calcium hydroxide. Discussions with NOSB staff since the November 20, 2000 submittal indicated that the Bio-Cal petition was under review and that we would soon receive written comments. To date written response to our petition has not been received. We attended the NOSB meeting in Lacrosse in June and committee members recommended that we resubmit petitions for each synthetic ingredient before July 1 for consideration at the next board meeting in November.

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It would be our preference to have a material listed as a calcium complex which includes calcium oxide and calcium hydroxide in a hydrated form that does not generate heat when in contact with soil or water. The listing of Bordeaux Mixes as a synthetic for use in organic crop production is an example of a material that is a mixture of substances including hydrated lime (hydrated lime by its nature likely also includes some calcium oxide). Following committee members advice, we are revising our submittal to request that calcium oxide (lime) and calcium hydroxide (hydrated lime) be listed as a synthetic substance for the production of organic crops. While we believe that fluidized bed reactor ash is an excellent source of calcium and sulfur, it is not an essential component of Bio-Cal and therefore we are not petitioning for its inclusion on the list. Mined gypsum can be used as a substitute. While the bottom ash from a fluidized bed reactor works better and avoids the environmental impact of mining virgin gypsum, we feel the approval process will be easier if we do not request the inclusion of bottom ash.

In "The Albrecht Papers, Volume II, Soil Fertility and Animal Health" Acres U.S.A., 1975, an entire chapter is entitled "Calcium, the Premier of the Soil's Nutrient Elements". Dr. William A. Albreht wrote, "We have long been liming the soil to grow legumes. But we have erroneously valued the limestone, i.e., the calcium carbonate, in that service because the carbonate part, or the chemical anion, was a means of reducing the concentration of the hydrogen ion, which is the acidity element of the soil. We failed to see the calcium, the chemical cation, as the foremost nutrient element required as an addition to the humid, highly-developed soils if they are to grow protein-rich forages." Dr. Albrecht further wrote, "also, calcium is the prime element in the nutrition of the plants which are giving us the various organic products serving to bring good animal health via good animal nutrition."

One of the reasons that we originally requested that soluble calcium complexes in the form of Bio-Cal be listed was that we felt that the calcium oxide and the calcium hydroxide ingredients needed to be in a form that did not burn microorganisms, soils or crops. Further we felt that these compounds should only be added to soils under the direction of a crop specialist that tests the soils fertility and adds the type of nutrients the soil needs. Bio-Cal is only supplied to farms that participate in a managed program where the best soil supplement is added to maintain soil fertility and mineralization. We recommend that calcium oxide and calcium hydroxide be used as part of a managed program to improve soil fertility and mineralization that it be applied in a form that does not release heat when it contacts water.

We would like to point out that we are not requesting that calcium oxide and calcium hydroxide be used to adjust soil pH to optimum levels. There are other products such as limestone that can adjust soil pH. We are requesting that these materials be allowed when it is necessary to re-mineralize soil and in particular raise the calcium level of soils. Many soils have a suitable pH range, but do not have sufficient minerals. The calcium ingredients in Bio-Cal are very available to crops. Research presented in our petition shows that forage grown on soils that have received these calcium ingredients have significantly higher levels of soluble minerals. The direct benefit from higher soluble mineral forage is that dairy cows in particular require less mineral supplement and are healthier.

Dairy cows are a good example of the need for a soluble source of calcium. The calcium in milk provides minerals necessary for strong bones in humans. Milk has long been recognized as a good source of calcium. It is then logical that dairy cows need a lot of calcium to produce milk and maintain their health. They come by this calcium either through mineral supplements that are added to their ration or by the calcium inherent in the food they eat. Cows that consume forages high in soluble calcium are healthier. Dairy farms are often located in hilly regions of Midwest states that lend themselves to smaller family owned dairy operations. These soils often suffer from demineralization. We have found that these soils can be re-mineralized by the addition of soluble calcium complexes. Soluble calcium complexes are an important source of calcium. Calcium also aids in the transport of other minerals. It is often the key to higher quality forages that lessen the need to add minerals to the rations of dairy cows.

We are petitioning for the inclusion of two compounds, calcium oxide and calcium hydroxide on the list of synthetic ingredients included on the list of crop supplements. We are including two sets of documents to support each request.

Thank you for your consideration in this matter.

Regards,

Floyd Meeker Jr.

Floyd Meeker, Jr.
Meeker Farms, Inc.
3659 Riverview Circle
Muscatine, IA 52761
Ph: 319-263-7429 Fax: 319-323-8767

Petition for Calcium Hydroxide 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.

Hydrated 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

3. Intended or current use of the substance.

Calcium hydroxide 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 hydroxide 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 hydroxide is formed from calcium oxide which 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 calcium complex 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 hydroxide 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. 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 hydroxide has been registered with the following State Departments for agricultural use.

State	Registration #
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 hydroxide is 1305-62-0.

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

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.

Calcium hydroxide does not produce heat when mixed with water. When properly buffered in a calcium complex such as Bio-Cal Calcium Complex, it 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 hydroxide is not toxic. Calcium is a common mineral found in nature. The calcium hydroxide 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 hydroxide 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 hydroxide. 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. <u>Safety information about the substance including a material data safety sheet (MSDS) and a substance report from the National Institute of Environmental Health Studies.</u>

The MSDS sheets are attached for calcium hydroxide and Bio-Cal which is a calcium complex containing calcium hydroxide. A side by side review of these two documents indicates that neither substance is a harsh or reactive chemical.

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

11. <u>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.</u>

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 hydroxide. 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.

Hydrated 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 hydroxide 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 hydrated 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 contaminates (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.

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 hydroxide (hydrated 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 remineralize soils.

Attachments: Bio-Cal Label

Material Safety Data Sheet – Bio-Cal

Material Safety Data Sheet – Calcium Hydroxide

State Registrations

Chemical Analysis

Toxicology information for Calcium Hydroxide

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

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

Component Name	% Found
Silicon	0.5-2
Aluminum	0.1-0.5
Iron	0.2-0.5

N

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.

ALDRICH CHEMICAL -- CALCIUM HYDROXIDE, 98+%, A.C.S. REAGENT, 23
MATERIAL SAFETY DATA SHEET
NSN: 681000N038024
Manufacturer's CAGE: 60928
Part No. Indicator: A
Part Number/Trade Name: CALCIUM HYDROXIDE, 98+%, A.C.S. REAGENT, 23

General Information

Company's Name: ALDRICH CHEMICAL CO
Company's P. O. Box: 355
Company's City: MILWAUKEE
Company's State: WI
Company's Country: US
Company's Zip Code: 53201
Company's Emerg Ph #: 414-273-3850
Company's Info Ph #: 414-273-3850
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SMJ
Date MSDS Prepared: 22JAN92
Safety Data Review Date: 21DEC92
MSDS Serial Number: BQVMJ
Hazard Characteristic Code: NK

Ingredients/Identity Information

Proprietary: NO
Ingredient: CALCIUM HYDROXIDE; (CALCIUM HYDRATE, SLAKED LIME)
Ingredient Sequence Number: 01
Percent: >98
NIOSH (RTECS) Number: EW2800000
CAS Number: 1305-62-0
OSHA PEL: 15 MG/M3 TDUST
ACGIH TLV: 5 MG/M3; 9293

Proprietary: NO
Ingredient: SUPP DATA: (SUCH AS NITROMETHANE, NITROETHANE, ETC.).
Ingredient Sequence Number: 02
NIOSH (RTECS) Number: 9999999ZZ
OSHA PEL: NOT APPLICABLE
ACGIH TLV: NOT APPLICABLE

Physical/Chemical Characteristics

Appearance And Odor: WHITE POWDER.

Fire and Explosion Hazard Data

Extinguishing Media: DRY CHEMICAL POWDER.
Special Fire Fighting Proc: WEAR NIOSH/MSHA APPROVED SCBA AND FULL PROTECTIVE EQUIPMENT (FP N) TO PREVENT CONTACT WITH SKIN AND EYES.
Unusual Fire And Expl Hazrds: EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): NONE SPECIFIED BY MANUFACTURER.
Materials To Avoid: STRONG ACIDS, ABSORBS CO*2 FROM AIR. HEATING CALCIUM HYDROXIDE-POTASSIUM NITRATE MIX W/CHLORINATED PHENOLS (SUPP DATA)

Hazardous Decomp Products: NONE SPECIFIED BY MANUFACTURER.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT

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Health Hazard Data

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LD50-LC50 Mixture: LD50: (ORAL,RAT) 7340 MG/KG
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: NO
Health Haz Acute And Chronic: ACUTE: HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN. MATERIAL IS EXTREMELY DESTRUCTIVE TO TISSUE OF THE MUCOUS MEMBRANES & UPPER RESPIRATORY TRACT, EYES & SKIN. INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION & EDEMA OF THE LARYNX & BRONCHI, CHEMICAL PNEUMONITIS & PULMONARY EDEMA. (EFTS OF OVEREXP
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT RELEVANT
Signs/Symptoms Of Overexp: HLTH HAZ: SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA & VOMITING.
Med Cond Aggravated By Exp: NONE SPECIFIED BY MANUFACTURER.
Emergency/First Aid Proc: EYE/SKIN: IMMEDIATELY FLUSH WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MIN WHILE REMOVING CONTAMINATED CLOTHING AND SHOES. SEEK MEDICAL ADVICE. INHAL: REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTF RESP. IF BREATHING IS DIFFICULT, GIVE OXYGEN. INGEST: WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN. WASH CONTAMINATED CLOTHING BEFORE REUSE.

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Precautions for Safe Handling and Use

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Steps If Matl Released/Spill: EVACUATE AREA. WEAR NIOSH/MSHA APPROVED SCBA, RUBBER BOOTS & HEAVY RUBBER GLOVES. ABSORB ON SAND OR VERMICULITE & PLACE IN CLOSED CNTNRS FOR DISP. VENT AREA AND WASH SPILL SITE AFTER MATL PICKUP IS COMPLETE.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: FOR SML QTYS:CAUTIOUSLY ADD TO A LRG STIRRED EXCESS OF WATER. ADJUST PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS/LIQS & PACKAGE THEM FOR HAZ-WASTE DISP. FLUSH AQUEOUS SOLN DOWN THE DRAIN W/PLENTY OF WATER. THE HYDROLYSIS & NEUTRALIZATION(SUPP DATA)
Precautions-Handling/Storing: DO NOT BREATHE DUST. DO NOT GET IN EYES, ON SKIN, ON CLOTHING. AVOID PROLONGED OR REPEATED EXPOSURE. CORROSIVE. KEEP TIGHTLY CLOSED.
Other Precautions: STORE IN A COOL DRY PLACE.

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Control Measures

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Respiratory Protection: WEAR APPROPRIATE NIOSH/MSHA APPROVED RESPIRATOR.
Ventilation: USE ONLY IN CHEMICAL FUME HOOD.
Protective Gloves: CHEMICAL-RESISTANT GLOVES.
Eye Protection: CHEM WORK GOG W/FULL LENGTH FSHLD (FP N)
Other Protective Equipment: SAFETY SHOWER AND EYE BATH. PROTECTIVE CLOTHING.
Work Hygienic Practices: WASH THOROUGHLY AFTER HANDLING. IMMEDIATELY TAKE OFF ALL CONTAM CLOTHING.
Suppl. Safety & Health Data: WAST DISP METH: RXNS MAY GENERATE HEAT AND FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION. DISPOSAL MUST BE IN MAY RESULT IN THE FORMATION OF CHLORINATED BENZODIOXINS. VIOLENT RXN W/ PHOSPHOROUS, MALEIC ANHYDRIDE, NITROPARAFFINS.(ING 2)

Transportation Data

Disposal Data

Label Data

Label Required: YES
Technical Review Date: 22DEC92
Label Date: 17DEC92
Label Status: G
Common Name: CALCIUM HYDROXIDE, 98+%, A.C.S. REAGENT, 23923-2
Chronic Hazard: NO
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Severe: X
Fire Hazard-None: X
Reactivity Hazard-None: X
Special Hazard Precautions: CORROSIVE. ACUTE: INGESTION, INHALATION OR SKIN ABSORPTION MAY BE HARMFUL. MATERIAL MAY CAUSE BURNS AND MAY BE EXTREMELY DESTRUCTIVE TO TISSUE OF MUCOUS MEMBRANES & UPPER RESPIRATORY TRACT, EYES AND SKIN. EXPOSURE MAY CAUSE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING. INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION & EDEMA OF LARYNX & BRONCHI, CHEMICAL PNEUMONITIS AND PULMONARY EDEMA. CHRONIC: NONE LISTED BY MANUFACTURER.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: ALDRICH CHEMICAL CO
Label P.O. Box: 355
Label City: MILWAUKEE
Label State: WI
Label Zip Code: 53201
Label Country: US
Label Emergency Number: 414-273-3850

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

DOING BUSINESS AS:

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

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

ID: 012601
VOLUME CERT: NO

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

License/Certification Categories

DISTRIBUTOR

Lic./Cert. No.	Lic./Cert. Fee Paid
20030448	$150.00

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

AG-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

LINWOOD 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

* * * 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	% Thru 4-MESH	% Thru 8-MESH	% Thru 60-MESH	% CACO3	% MOIST	Cert. Value
1)	2000/05/23	0685	94	82	38	97	14	948
2)	2000/04/12	0580	87	75	28	76	15	620
3)	2000/03/23	0537	87	77	35	77	14	699
4)	1999/11/24	0311	85	75	33	75	13	663
5)	1999/10/26	0194	90	83	40	79	16	768

Number of pounds of effective CACO3 per ton of aglime as of 06/01/2000 = 740

Sample Certification Computations:

+ 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 .6)

= 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

Certifications: A2LA Accredited • NRC • Wastewater & LUST
Website: qcmetaltesting.com • Email: metalab@qconline.com

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.

Element	Bio-Cal	Methods
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_2O Available	0.024	EPA 258.1
Fe_2O_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.

Element	Bio-Cal	Sol-U-Cal	Methods
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_2O Available	0.04	0.02	EPA 258.1
Fe_2O_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.

Element	Bio-Cal	Sol-U-Cal	Methods
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_2O Available	0.05	0.033	EPA 258.1
Fe_2O_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.

Element	Bio-Cal	Sol-U-Cal	Methods
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_2O Available	0.04	0.02	EPA 258.1
Fe_2O_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.

Element	Nod Dust	1 Kiln	Methods
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_2O Available	0.61	0.62	
Fe_2O_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.

Element	% by Wt.	Methods
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_2O Available	0.06	
Fe_2O_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_2O Available	0.06
Fe_2O_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

File under Meeker Farms.

To: Midwestern Bio-Ag
Dr. Bill Zimmer

Report #15481

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

Element	% by Wt.
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_2O Available	0.48
Fe_2O_3 Available	0.71

(all above data given in % by wt.)

% Moisture	3.59
pH (units)	12.013

< = less than

Faxed & mailed copy of Report to Butch Meeker 3/17/98

FILE

John O. Bloodsworth /LB
John O. Bloodsworth, P.E.

Douglas Darland/Chemist

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_2O Available	0.08	0.10
Fe_2O_3 Available	0.73	0.81
% Moisture	9.21	12.31
pH	12.77 units	12.78 units

Sample for heavy metals

Element	% by weight
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.

Parameter	Bio-Cal	Kiln Dust	Hyd. Tailings	Waste
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_2O Available	0.08	0.73	0.17	0.06
Fe_2O_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 Wt. %
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_2O Available	0.15
Fe_2O_3 Available	0.90
% Moisture	9.30
pH	12.37 units

John O. Bloodsworth, P.E.

Douglas Darland/Analyst

950

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

February 28, 1997

To: Meeker Farms
Butch Meeker

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_2O Available	0.08	0.10	0.08
Fe_2O_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
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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 Flag	Analyst	Date Analyzed	Method	Reporting Limit
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

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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 Flag	Analyst	Date Analyzed	Method	Reporting 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							COMPLE
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

NATIONAL ENVIRONMENTAL TESTING, INC.

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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 Flag	Analyst	Date Analyzed	Method	Reporting Limit
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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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

Analyte	Result	Units	Result Flag	Analyst	Date Analyzed	Method	Reporting Limit
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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ANALYTICAL REPORT

AMENDED REPORT

02/27/1998

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

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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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	COMPLETE
BNA - 8270 NONAQUEOUS						
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

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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.: 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	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: 440909

Project ID: Dioxin & PCB Bed Ash/LKD

Sample ID: Sample #1 Bed Ash

Date Taken:

Date Received: 03/10/1998

Analyte	Result	Units	Result Flag	Analyst	Date Analyzed	Method	Reporting Limit
% Solids	100	%		cjh	03/10/1998		
Prep. PEST/PCB'S NONAQUEOUS	complete			djl	03/06/1998	S-3540	
DIOXIN Equivalent	<5.0	ppt		rlb	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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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

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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
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

Analyte	Result	Units	Result Flag	Analyst	Date Analyzed	Method	Reporting Limit
% Solids	97.98	%		cjh	03/10/1998		
Prep. PEST/PCB'S NONAQUEOUS	complete			djl	03/06/1998	S-3540	
DIOXIN Equivalent	<5.0	ppt		rlb	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

NET® 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

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

NET®
NATIONAL ENVIRONMENTAL TESTING, INC.

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

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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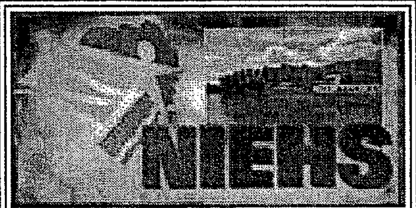

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9th Report on Carcinogens Available

Nomination for David P. Rall Award for Advocacy in Public Health

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National Toxicology Program

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 Server
How to NOMINATE a chemical

NTP Participating Agencies

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NIOSH --- CDC

- NTP Background
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- Testing Information & Study Results
- NTP Report on Carcinogens
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  -- Alternative Toxicological Methods
  -- Risks to Human Reproduction
  -- NTP Center for Photoxicology
- 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.

EPA United States Environmental Protection Agency

Envirofacts Warehouse Chemical References

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Envirofacts Warehouse Chemical References

CALCIUM HYDROXIDE CAS #1305-62-0

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:

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.

ENVIRONMENTAL DEFENSE

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ABOUT THE CHEMICALS | Chemical Profile

Environmental Defense Scorecard

Chemical: CALCIUM HYDROXIDE
CAS Number: 1305-62-0

Chemical Profile for CALCIUM HYDROXIDE (CAS Number: 1305-62-0)

- **Human Health Hazards**

Health Hazard	Reference(s)
Recognized:	--
Suspected:	--

[top]

- **Hazard Rankings**

Less hazardous than most chemicals in 3 ranking systems.

[top]

- **Chemical Use Profile**

Used in at least 2 industries.
Used in consumer products, building materials or furnishings that contribute to indoor air pollution.

[top]

- **Profile of Environmental Release and Waste Generation**

  No data on environmental releases in Scorecard.

[top]

- **Regulatory Coverage**

  On at least 1 federal regulatory list.

[top]

- **Basic Testing to Identify Chemical Hazards**

  Information on whether basic tests to identify chemical hazards have been conducted on this chemical is not available.

[top]

- **Information Needed for Safety Assessment**

  Lacks at least some of the national data required for safety assessment.
  No data on risk assessment values in Scorecard.

[top]

- **Links**

  Other web sites specific to this chemical:
  - IPCS International Chemical Safety Card

  If none of these sources meet your needs, you can try searching some other chemical database Web sites.

[top]

Benjamin_Smith@environmentaldefense.org

ENVIRONMENTAL DEFENSE

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ABOUT THE CHEMICALS | **Hazard Rankings**

Chemical: CALCIUM HYDROXIDE
CAS Number: 1305-62-0

Least Hazardous

Percentile
25% 50% 75

Human Health Rankings

Toxicity and exposure potential
Worker Exposure Hazard Score (IRCH)

Ecological Health Rankings

Toxicity and persistence
Environmental Hazard Value Score (IRCH)

Integrated Environmental Rankings

Combined human and ecological scores
Total Hazard Value Score (IRCH)

Benjamin_Smith@environmentaldefense.org

International Chemical Safety Cards

CALCIUM HYDROXIDE

ICSC: 0408

National Institute for Occupational Safety and Health

NIOSH

CALCIUM HYDROXIDE
Calcium dihydroxide
Calcium hydrate
Hydrated lime
Slaked lime
$Ca(OH)_2$
Molecular mass: 74.1

CAS # 1305-62-0
RTECS # EW2800000
ICSC # 0408

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.
EXPLOSION			
EXPOSURE		PREVENT DISPERSION OF DUST!	
• INHALATION	Sore throat. Cough. Burning sensation.	Local exhaust or breathing protection.	Fresh air, rest. Refer for medical attention.
• SKIN	Redness. Roughness. Pain. Dry skin. Skin burns. Blisters.	Protective gloves. Protective clothing.	Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention.
• EYES	Redness. Pain. Severe deep burns.	Safety goggles, or face shield, 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.	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 containers, then remove to safe place (extra personal protection: P2 filter respirator for harmful particles).	Separated from strong acids.	

SEE IMPORTANT INFORMATION ON BACK

ICSC: 0408

International Chemical Safety Cards

CALCIUM HYDROXIDE

ICSC: 0408

IMPORTANT DATA

PHYSICAL STATE; APPEARANCE:
COLOURLESS CRYSTALS OR WHITE POWDER.

PHYSICAL DANGERS:

CHEMICAL DANGERS:
The substance decomposes on heating producing calcium oxide. The solution in water is a medium strong base. Reacts violently with acids. Attacks many metals in presence of water forming flammable/explosive gas (hydrogen - see ICSC # 0001.

OCCUPATIONAL EXPOSURE LIMITS (OELs):
TLV: 5 ppm; mg/m^3 (ACGIH 1996).
OSHA PEL: TWA 15 mg/m^3 (total) 5 mg/m^3 (resp)
NIOSH REL: TWA 5 mg/m^3
NIOSH IDLH: No data

ROUTES OF EXPOSURE:
The substance can be absorbed into the body by inhalation of its aerosol and by ingestion.

INHALATION RISK:
Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed.

EFFECTS OF SHORT-TERM EXPOSURE:
The substance irritates the respiratory tract and is corrosive to the eyes and the skin. Medical observation is indicated.

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.

PHYSICAL PROPERTIES

Melting point (decomposes): 580°C
Relative density (water = 1): 2.2
Solubility in water: none

ENVIRONMENTAL DATA

NOTES

ADDITIONAL INFORMATION

ICSC: 0408 CALCIUM HYDROXIDE

IMPORTANT LEGAL NOTICE:
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.

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- MEDLINE
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- MESH HEADING
- RTECS
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Internet Locators

- EPA Envirofacts
- NIOSH ICSC
- NIOSH Pocket Guide
- NIST WebBook

Superlist Locator

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- FIFR
- GRAS
- INER
- MA
- PA
- PAFA
- PEL
- PELS
- REL
- TLV

WHMI

Calcium dihydroxide

- **Formula:** H_2CaO_2
- **Molecular Weight:** 74.09
- **CAS Registry Number:** 1305-62-0
- **Chemical Structure:**

This structure is also available as a 2d Mol file.
- **Other Names:** Calcium Hydroxide; Calcium hydrate; Hydrated lime; Lime water; Ca(OH) 2; Calcium hydroxide (Ca(OH)2); Bell mine; Kemikal; Slaked lime
- Notes / Error Report
- **Other Data Available:**
    - Gas phase thermochemistry data
    - Condensed phase thermochemistry data
    - Reaction thermochemistry data
    - Gas phase ion energetics data
    - Vibrational and/or Electronic Spectra
- Switch to calorie-based units

Notes / Error Report

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- Data from NIST Standard Reference Database 69 - February 2000 Release: *NIST Chemistry WebBook*
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CALCIUM HYDROXIDE

CASRN: 1305-62-0

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

A. ACUTE POISONING: 1. INGESTION- INGESTION OF ALKALI IS FOLLOWED BY SEVERE PAIN, VOMITING, DIARRHEA, & COLLAPSE. VOMITUS CONTAINS BLOOD & DESQUAMATED MUCOSAL LINING. IF DEATH DOES NOT OCCUR IN FIRST 24 HR, PT MAY IMPROVE ... 2-4 DAYS ... THEN ... ONSET OF SEVERE ABDOMINAL PAIN, RAPID FALL OF BLOOD PRESSURE INDICATING DELAYED GASTRIC OR ESOPHAGEAL PERFORATION. ... ESOPHAGEAL STRICTURE CAN OCCUR WK, MO, OR ... YR LATER TO MAKE SWALLOWING DIFFICULT. /ALKALIES/

[Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987. 211]**PEER REVIEWED**

A. ACUTE POISONING: 3. ALKALIES PENETRATE SKIN SLOWLY. EXTENT OF DAMAGE ... DEPENDS ON DURATION OF CONTACT. B. CHRONIC POISONING (FROM SKIN CONTACT): CHRONIC DERMATITIS MAY FOLLOW REPEATED CONTACT WITH ALKALIES. /ALKALIES/

[Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987. 213]**PEER REVIEWED**

CALCIUM HYDROXIDE IN VARIOUS FORMS IS ONE OF THE COMMONEST CAUSES OF SEVERE CHEMICAL BURNS OF EYE, MOST COMMONLY KNOWN AS "LIME BURNS".

[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 167]**PEER REVIEWED**

MILD LIME BURNS ... TYPICALLY CAUSE A FROSTED OR GROUND GLASS TYPE OF OPACITY LOCATED ... SUPERFICIALLY APPROX AT THE LEVEL OF BOWMAN'S MEMBRANE, RESEMBLING BAND KERATOPATHY OF HYPERCALCEMIA IN ITS BIOMICROSCOPIC APPEARANCE. IT IS FREQUENTLY SEEN IN PATIENTS WITH CONSIDERABLE LOSS OF EPITHELIUM BUT NO UNDERLYING OPACITY OF THE STROMA. THIS THIN LAMINA OR VEIL OF OPACITY MAY BE COVERED BY THE CORNEAL EPITHELIUM WHEN IT REGENERATES, RETAINING A CLOSE RESEMBLANCE TO CALCIFIC BAND KERATOPATHY. THE OVERLYING EPITHELIUM HAS TO BE REMOVED BEFORE THE DEPOSIT CAN BE DISSOLVED BY EDETATE (EDTA) SOLUTION.

[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 217]**PEER REVIEWED**

CORNEAS SEVERELY BURNED BY CALCIUM HYDROXIDE ... TYPICALLY ARE ANESTHETIC FOR MANY DAYS AFTER THE INJURY ... PRESUMED DUE TO DAMAGE OF CORNEAL NERVES.

[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 168]**PEER REVIEWED**

HUMAN DENTAL PULPS OBTAINED FROM 33 NONCARIOUS TEETH EXTRACTED FROM YOUNG ADULTS WERE CULTIVATED IN VITRO. CALCIUM HYDROXIDE (CA(OH)2), COTTON & SILVER WERE NONTOXIC WHILE ZINC OXIDE-EUGENOL PASTE WAS TOXIC WHEN EACH WAS TESTED IN PROXIMITY WITH CELLS.

[DAS S; ORAL MED ORAL PATHOL 52 (1): 76-84 (1981)]**PEER REVIEWED**

... Lime burns of the eye are caused by a splash of a thick, moist, pasty material (plaster, mortar, or cement), less commonly by a splash of milky fluid (whitewash) and rarely by a clear solution of calcium hydroxide (lime water).
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 167]**PEER REVIEWED**

... LIME, PLASTER, OR CEMENT ON REACHING EYE TENDS TO REACT WITH MOISTURE & PROTEIN ... & FORM CLUMPS OF MOIST CMPD, 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 ...
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 524]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Skin irritant.
[Hawley, G.G. The Condensed Chemical Dictionary. 10th ed. New York: Van Nostrand Reinhold Co., 1981. 182]**PEER REVIEWED**

Dust irritates eyes, nose and throat.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Probable Routes of Human Exposure:

IN FORM OF DUST IT IS CONSIDERED ... IMPORTANT INDUSTRIAL HAZARD.
[Sax, N.I. Dangerous Properties of Industrial Materials. 5th ed. New York: Van Nostrand Rheinhold, 1979. 462]**PEER REVIEWED**

GENERAL PURPOSE FOOD ADDITIVE ... SUBSTANCE MIGRATING TO FOOD FROM PACKAGING MATERIAL ... .
[Sax, N.I. Dangerous Properties of Industrial Materials. 5th ed. New York: Van Nostrand Rheinhold, 1979. 462]**PEER REVIEWED**

The National Occupational Hazard Survey conducted by NIOSH estimated that 399 workers may be exposed to calcium hydroxide; 100% from actual observed use, 0% from observed use of a tradename product known to contain this chemical, and 0% from observed use of a product in some type of general use which leads NIOSH to suspect that this chemical may be contained in the product.
[NIOSH National Hazard Exposure Survey (1972-1974)]**PEER REVIEWED**

EMIC Search Results

Items 1 through 9 of 9

References are sorted in relevancy ranked order.
*Click on **Sort** to change the order of the retrieved References.*

Select Record	Reference	Words Found
1	SCIENTIFIC LITERATURE REVIEWS ON GENERALLY RECOGNIZED AS SAFE (GRAS) FOOD INGREDIENTS: CALCIUM HYDROXIDE AND CALCIUM OXIDE INFORMATICS I NTIS PB REPORT (PB-223 851):22 PP,1973	1305-62-0 emic
2	PRELIMINARY ASSESSMENT OF POSSIBLE MUTAGENICITY OF BETEL NUT AND INGREDIENTS OF THE BETEL QUID WHEN ADMINISTERED ALONE OR IN COMBINATIONS TO LARVAE OF DROSOPHILA MELANOGASTER ABRAHAM SK; GOSWAMI V; KESAVAN PC MUTAT RES 66:261-266,1979	1305-62-0 emic
3	MUTAGENICITY OF DENTAL MATERIALS, DRUGS AND METAL COMPOUNDS KANEMATU N; SHIBATA K J DENT RES 59(SPEC ISSUE B):956,1980	1305-62-0 emic
4	APPLICATION OF THE MICRONUCLEUS TEST TO EXFOLIATED CELLS OF HIGH CANCER RISK GROUPS: TOBACCO CHEWERS STICH HF; CURTIS JR; PARIDA BB INT J CANCER 30:553-559,1982	1305-62-0 emic
5	MUTAGENICITY OF DENTAL ROOT CANAL FILLING MATERIALS: GROUPS OF IODOFORM NAKASHIMA K; YOSHITSUGU K J DENT RES 62:653,1983	1305-62-0 emic
6	ORAL LESIONS, GENOTOXICITY AND NITROSAMINES IN BETEL QUID CHEWERS WITH NO OBVIOUS INCREASE IN ORAL CANCER RISK STICH HF; ROSIN MP; BRUNNEMANN KD CANCER LETT 31:15-25,1986	1305-62-0 emic
7	REDUCING THE GENOTOXIC DAMAGE IN THE ORAL MUCOSA OF BETEL QUID/TOBACCO CHEWERS, IN: ANTIMUTAGENESIS AND ANTICARCINOGENESIS MECHANISMS STICH HF BASIC LIFE SCI 39:381-391,1985	1305-62-0 emic
8	THE DNA-DAMAGING ACTIVITY OF NATURAL FOOD ADDITIVES. 4. ISHIZAKI M; UENO S SHOKUHIN EISEIGAKU ZASSHI(J FOOD HYG SOC JAPAN) 28:498-501,1987 [Japanese]	1305-62-0 emic

9 CYTOLOGICAL EFFECT OF CHEMICALS ON TUMORS. 16. EFFECT OF SOME INORGANIC COMPOUNDS ON THE MTK-SARCOMA III IN VIVO 1305-62-0 emic
KIMURA Y; MAKINO S
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National Library of Medicine - Medical Subject Headings

2000 MeSH

MeSH Descriptor Data

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MeSH Heading	Calcium Hydroxide
Tree Number	D01.146.335
Tree Number	D01.455.275
Annotation	wide use in med, agric & industry
Scope Note	Calcium hydroxide (Ca(OH)2). A white powder that has many therapeutic uses. Because of its ability to stimulate mineralization, it is found in many dental formulations.
Allowable Qualifiers	AD AE AG AI AN BL CF CH CL CS CT DU EC HI IM IP ME PD PK PO RE SD ST TO TU UR
CAS Type 1 Name	Calcium hydroxide (Ca(OH)2)
Registry Number	1305-62-0
Previous Indexing	Calcium (1966)
Previous Indexing	Hydroxides (1966)
History Note	67
Unique ID	D002126

MeSH Tree Structures

Inorganic Chemicals [D01]
- Calcium Compounds [D01.146]
  - Calcium Carbonate [D01.146.275]
  - Calcium Chloride [D01.146.300]
  - Calcium, Dietary [D01.146.315]
  - Calcium Fluoride [D01.146.325]
  - ► Calcium Hydroxide [D01.146.335]
  - Calcium Phosphates [D01.146.360] +
  - Calcium Sulfate [D01.146.375]
  - Cyanamide [D01.146.400]

Inorganic Chemicals [D01]
Hydroxides [D01.455]
- Aluminum Hydroxide [D01.455.150]
- ➤ Calcium Hydroxide [D01.455.275]
- Hydroxyl Radical [D01.455.432]
- Lye [D01.455.450]
- Magnesium Hydroxide [D01.455.550]
- Sodium Hydroxide [D01.455.824]
- Water [D01.455.900] +

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TOXLINE Search Results

Items **1** through **20** of **537**

Page **1** of **27**. Go to page

References are sorted in relevancy ranked order.
*Click on **Sort** to change the order of the retrieved References.*

Select Record	Reference
1	**Calcium hydroxide, a possible antidote for shin oak (Quercus havardi) poisoning in cattle.** Dollahite JW ; Housholder GT ; Camp BJ Southwestern Vet, Vol. 16, p. 115-117, 1963 [PPBIB]
2	**Oak poisoning in livestock.** Dollahite JW ; Housholder GT ; Camp BJ Texas Agr Exp Sta Bull, Vol. #1049, p. 1-8, 1966 [PPBIB]
3	**A geographic study of the relationship between oral cancer and plants.** Dunham LJ Cancer Res, Vol. 28, Nov, p. 2369-2371, 1968 [PPBIB]
4	**Biological effects of root canal filling materials. V. Toxic effect in vitro of root canal filling materials on HeLa cells and human skin fibroblasts.** SPANGBERG L ODONTOL REVY; 20 (4). 1969 427-436 [HEEP]
5	**Volumetric Method for Determination of Fluorine** Willard HH ; Winter OB Industrial and Engineering Chemistry, Analytical Edition, Vol. 5, No. 1, pages 7-10, 19 references, 19331933 [NIOSH]
6	**Data On The Toxicity Of Benzimine, Diethyl Toluamide, And Carboxide For Warm-Blooded Animals** Leshchev VV Trudy, Vsesoyuznyi Nauchno-Issledovatel'skii Institut Veterinarnoi Sanitarii, Vol. 3, pages 228-234, 19691969 [NIOSH]
7	**Electro-chelation: Principles and results in corneoconjonctival burns caused by lime.** RADIAN AB ; RADIAN AL ; OUDRESCO A ; MICHEL I ; JAVORSKY E ANN OCUL; 205 (9). 1972 1013-1018 [HEEP]
8	**INTERSPECIES VARIATION IN DERMAL REACTIVITY** DAVIES RE ; HARPER KH ; KYNOCH SR J SOC COSMET CHEM; 23 (7). 1972 371-381 [HEEP]
9	**Pulp capping with calcium hydroxide or zinc oxide and eugenol: Comparative histological study in dogs.** DE MELLO W ; HOLLAND R ; DE SOUZA V REV FAC ODONTOL ARACATUBA; 1 (1). 1972 (RECD 1973) 33-43 [HEEP]
10	**METHODS FOR ELIMINATION OF GOSSYPOL TOXICITY IN UNEXTRACTED COTTONSEED MEATS** CLAWSON AJ ; MANER JH ; GOMEZ G ; MEJIA O ; FLORES Z ; BUITRAGO J J ANIM SCI; 38 (1). 1974 221 [HEEP]

11 **THE EFFECTS OF ALKALINE EARTH HYDROXIDES ON ESCHERICHIA-COLI AND COLIFORMS IN SEWAGE**
WEST LA ; MORRISON SM
ABSTR ANNU MEET AM SOC MICROBIOL; 74. 1974 36 [HEEP]

12 **CLINICAL STUDY OF HUMAN DENTAL ROOT FILLED WITH A CALCIUM HYDROXIDE BARIUM SULFATE AND PROPYLENE GLYCOL PASTE**
LAWA AJ
J DENT RES; 53 (3). 1974 713 [HEEP]

13 **STUDIES ON THE USE OF OZONE FOR WATER AND SEWAGE PURIFICATION**
REICHERTER U ; SONTHEIMER H
HUSMANN, W. (ED.). VOM WASSER, BAND 41. (ON WATER, VOL. 41). (IN GER.). VIII+487P. ILLUS. VERLAG CHEMIE: WEINHEIM, WEST GERMANY. ISBN 3-527-25546-X.; 1973 (1974) (RECD 1975) 369-380 [HEEP]

14 **Unextracted cottonseed in diets for monogastric animals: I. The effect of ferrous sulfate and calcium hydroxide in reducing gossypol toxicity.**
CLAWSON AJ ; MANER JH ; GOMEZ G ; MEJIA O ; FLORES Z ; BUITRAGO J
J ANIM SCI; 40 (4). 1975 640-647 [HEEP]

15 **Brief communication: Argyrophilic carcinoids in two Syrian hamsters (Mesocricetus auratus).**
DUNHAM LJ ; SNELL KC ; STEWART HL
J NATL CANCER INST; 54 (2). 1975 507-514 [HEEP]

16 **The neutralizing capacity of 12 different lime products used for pH-adjustment of acid water.**
GRAHN O ; HULTBERG H
VATTEN; 31 (2). 1975 120-132 [HEEP]

17 **Reaction of the human dental pulp to silver amalgam restorations: The modifying effect of treatment with calcium hydroxide.**
MOLLER B
ACTA ODONTOL SCAND; 33 (4). 1975 233-238 [HEEP]

18 **Pulpal effects of Nuva Seal on dogs' teeth.**
GOTO G ; MACHIDA Y
BULL TOKYO DENT COLL; 17 (1). 1976 45-55 [HEEP]

19 **Histopathologic evaluation of the effects of four calcium hydroxide liners on monkey pulps.**
HEYS DR ; HEYS RJ ; FOX CF ; AVERY JK
J ORAL PATHOL; 5 (3). 1976 129-148 [HEEP]

20 **Effect of alkali treatment on the formation of lysinoalanine in corn.**
CHU NT ; PELLETT PL ; NAWAR WW
J AGRIC FOOD CHEM; 24 (5). 1976 1084-1085 [HEEP]

Items **1** through **20** of **537**

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NOSB Materials Database

Identification

Common Name Lime, Hydrated

Chemical Name

Other Names Dolomitic Hydrated Lime

Code #: CAS

Code #: Other

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.

Internationl 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 Sacromento, 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 repellant.
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. Plats 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 plats 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 ere 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 n 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/l 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 Ca(OH)2 at four rates, high-magnesic 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-magnesic 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 K2O, 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; 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 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)

8.

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 1.9-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:

Plot	Replication 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 limstone	66.7	69.4	66.7	67.6	67.6	1.27

Site 2:

Plot	Replication 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 limstone	83.3	91.7	84.3	72.2	82.9 D	8.04

Site 3:

Plot	Replication 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 limstone	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 <u>not</u> 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.

Parameter	MBA samples	All samples	Change
% 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.

Parameter	MBA samples vs. All samples Change
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.

Supplement		Amount needed daily
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		0.094086 Lbs.
	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 Lbs./cow/day x 50 cows x 365 days/year = 8,149 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 phophorus and potash fertility. (Please refer to attached sheets titled Feed and Forge Report, #001446 and #001447, dated 6/5/96.)

Parameter	MBA samples	All samples	Change
% 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.

Parameter	MBA samples vs. All samples Change	
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.

Supplement	Amount needed daily
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

	Average of Dairyland Labs Mixed Haylage Samples		Dairyland Labs Samples from Bio-Ag Farms With confirmed use of MBA fertility program		
Test	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

500# 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)

		RY BASIS:		S IS:	
RESULTS:	Moisture			84.59%	
	Dry Matter			15.41%	
	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

IRYLAND LABORATORIES, INC. - Arcadia

SAMPLED BY: Bob Schmidtknecht
SAMPLED FOR: WOYCHIK BROS.
RODUCT: #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

REPRINT OF ORIGINAL
Report date: 6/ 5/96 Sample number: 001447

ACCOUNT # 554 (6)
TO: Bob Schmidtknecht
W26857 Mesa Lane
Arcadia, WI 54612

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

1995 Treatment	Organic Matter	pH	Bray P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
				ppm									
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

1997 Treatment	Organic Matter	pH	Bray P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
				ppm									
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

1999 Treatment	Organic Matter	pH	Bray P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
				ppm									
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

1995 Treatment	Organic Matter	pH	Bray P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
				ppm									
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

2000-A Treatment	Organic Matter	pH	Bray P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
				ppm									
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

2000-M Treatment	Organic Matter	pH	Bray P1	P2	K	Mg	Ca	S	Zn	Mn	Fe	Cu	B
				ppm									
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	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)	Al (ppm)	Na (ppm)
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	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)	Al (ppm)	Na (ppm)
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. What ever 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?

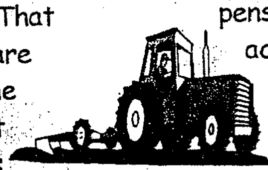
All fertilizers are not created equal. What makes Midwestern Bio-Ag fertilizers different?

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.

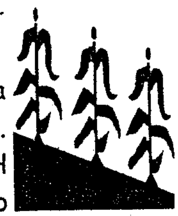
2. Soluble and slow release All the desirable nutrients in the world may be present in a fertilizer, but if they are unavailable to the plant when the plant needs them, the crop will suffer.

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.

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

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. 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. <u>Fertilizer form</u> 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.

> **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 pHs

☑ 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.

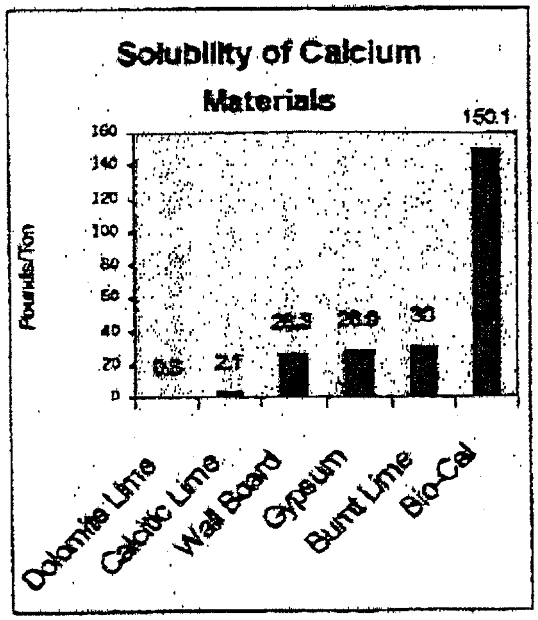
Bio-Cal meets all established levels set by state and federal agencies for all contaminants (heavy metals, dioxins and other compounds) for land applied products. Tested extensively, Bio-Cal has been found to be very clean compared to other byproducts, and is as safe or safer than naturally mined materials.

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



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 4)

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 1.5 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.

10 DIII - from Butch Meeker

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

"Nutrition from the Soil Up"

	Average of Dairyland Labs Arcadia, Wisconsin Mixed Haylage Samples		Dairyland Labs Samples from Midwestern Bio-Ag Farms with Confirmed Use of MBA Fertility Program.		
Test	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, <u>Mineralized Plant</u> provides better livestock nutrition!

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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 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 five pounds or less per ton," Zimmer 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."

A 1995-97 feed test study conducted by MBA compared results from 295 farms using Bio-Cal on haylage samples versus 35,000 samples tested by Dairyland Labs.

"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."

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-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.

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To Bill From Butch Meeker Oct, 2000


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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. ◆

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 bactrins 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.

MIDWESTERN BIO - AG

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

Midwestern Bio-Ag
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Blue Mounds, WI 53517
1-800-327-6012
FAX 1-608-437-4441
www.midwesternbioag.com

Bio-Ag of Michigan
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Kinde, MI 48445
1-888-825-9373
FAX 1-517-874-5009

Iowa Bio-Ag
17712 Spring Street, Box 49
Langworthy, IA 52252
1-888-465-3503
FAX 1-319-465-3468

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.

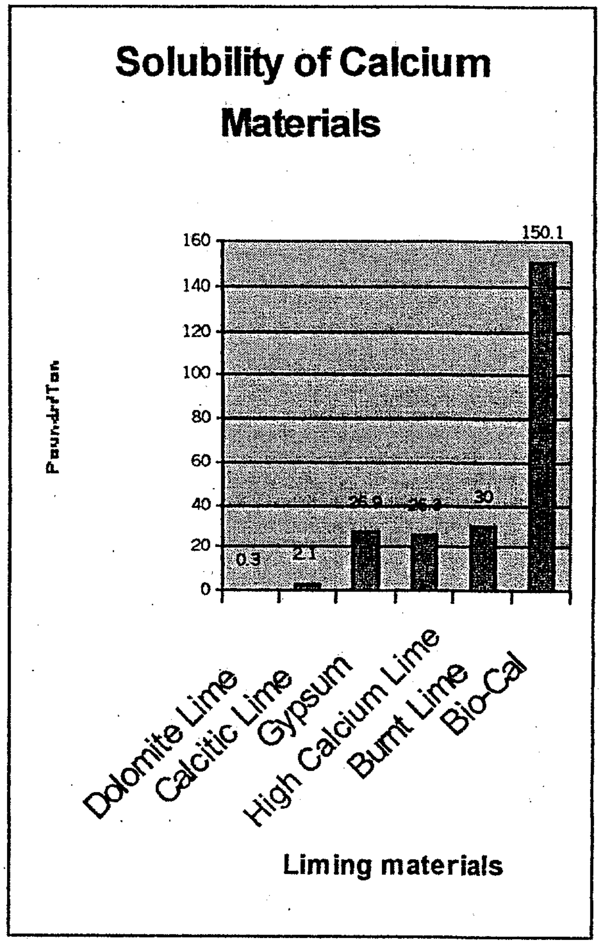
--Does not appreciably raise pH.

-- 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.



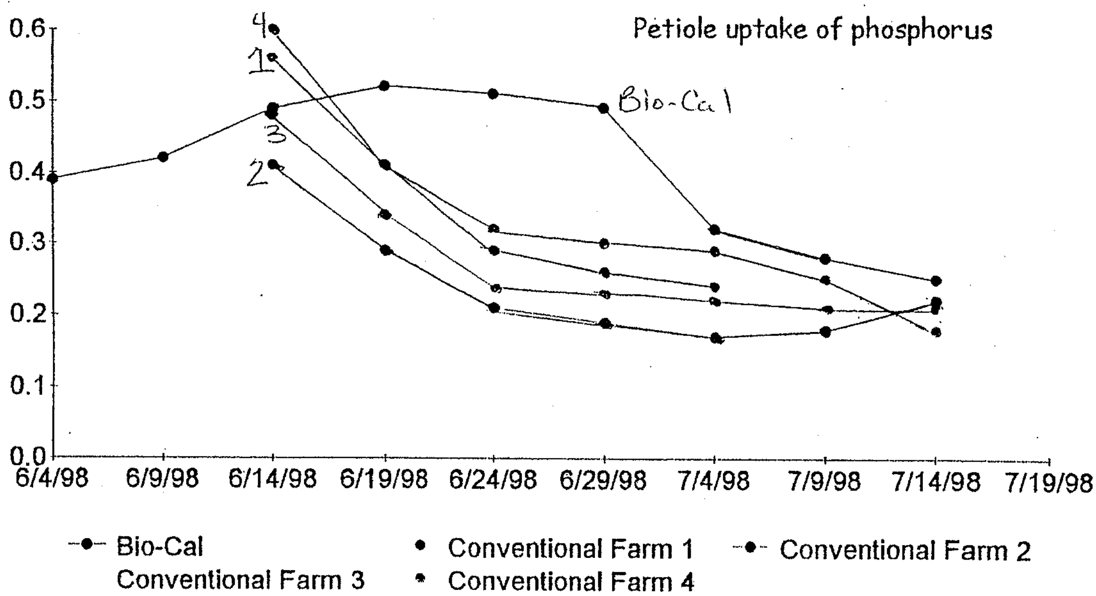
—Many farmers report reduced need for N-P-K when using Bio-Cal.

How does Bio-Cal compare with Calcium Nitrate?

-- Lower cost
-- Contains extra nutrients
  --sulfur
  --trace elements
-- Studies show improved phosphorus uptake

	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)

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."

THE BIOLOGICAL FARMER

A Complete Guide to the Sustainable & Profitable Biological System of Farming

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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.

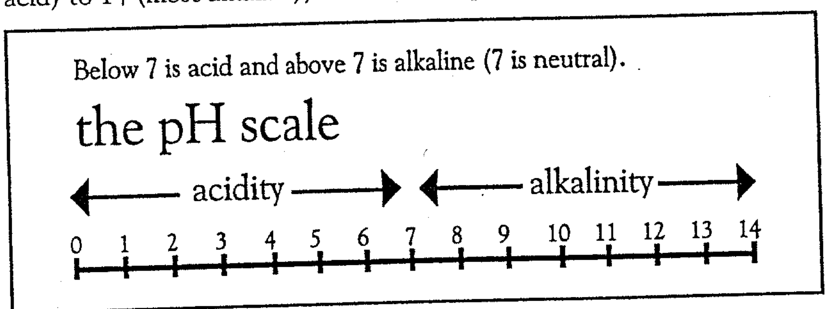
What is pH?

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, $Ca^{+} + CO_3^{-}$. 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.)

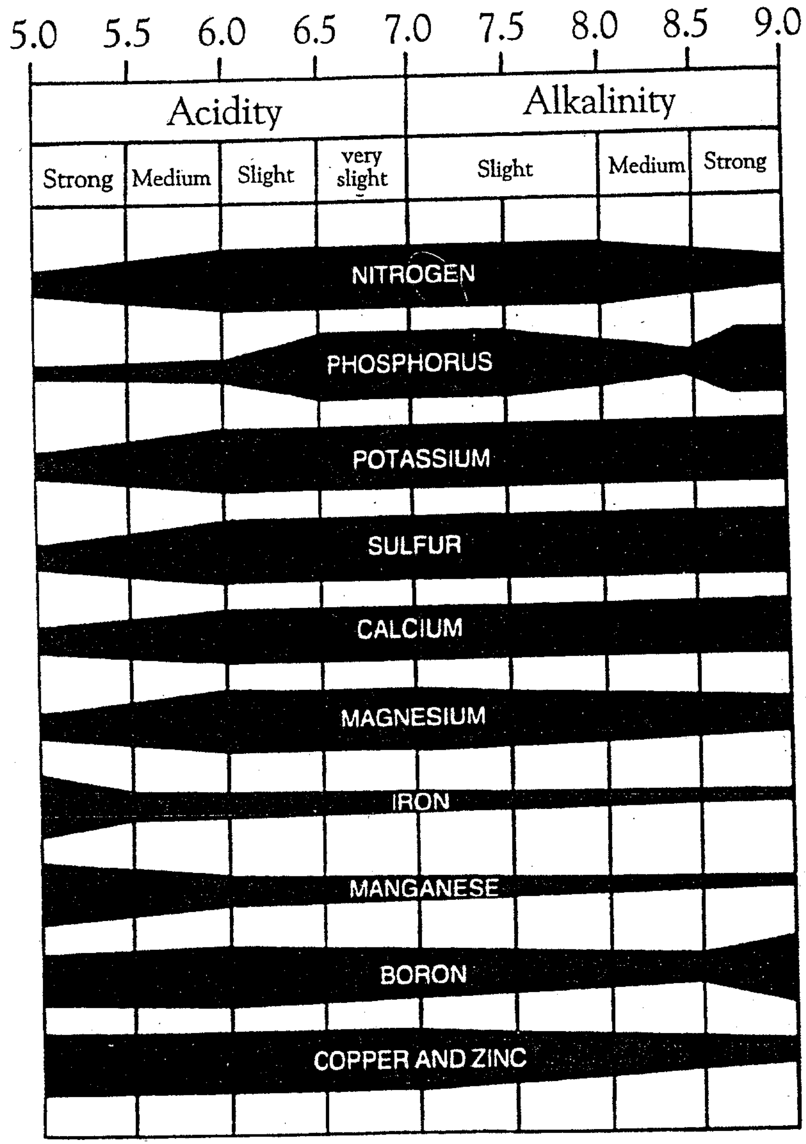
Soil pH also affects the activity of beneficial soil microbes. Bacteria and actinomycetes prefer alkaline pHs, while fungi do best in acid conditions. Plants grow better when beneficial organisms are abundant in the soils (see Chapter 5), so a soil pH that is not too acid and not very alkaline is a good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

$$H^{+} + OH^{-} = H_2O$$



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^+ + and CO_3^-. The carbonate ion combines with two hydrogen ions, neutralizing the acidity:

$$CO_3^- + 2H^+ = H_2O + CO_2$$

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 & F.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, $CaCO_3 \cdot MgCO_3$) — 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	
Average:		1995	1997	1995	1997	1995	1997
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_2O_5	8%	9%
K_2O	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 Faith Ex 91"

Gar-Ville Farm

Robert [illegible] • Phone [illegible] • Cochrane, Wisconsin 54622

Butch

Several more Questionares

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

B J Monks

M.B.A. BIO-CAL Questionnaire

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

2) How many years have you used Bio-Cal? 5 yrs

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

4) At what application rate? 500 #

5) Did you see a difference in the soil tests before and after? Yes The Trace Minerals in the Soil Became Higher, I Believe Because of the Breaking Down of Organic Residues, and it releases some essential Nutrients

6) Did you take feed tests on the crops? Yes everthing Seemed To Be Higher like Calcium, Phos, Mag, Etc. and how the protein seemes To Be more available

7) Did you see any significant difference in the calcium levels after using Bio-Cal? Yes
It almost Seem to double

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? ~~Better~~ no ~~Higher~~ ~~yeilds~~

b) If so what effects? Better Higher Yeilds

Date: 10/28/00 Signature: B. J. Monks

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

* Crops Looked Better, deeper green color. corn had much larger ears.

M.B.A. BIO-CAL Questionnaire

1) Have you used Bio-Cal? Yes *✓* No______

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

3) Which crops? Corn *✓* Soybeans______

Alfalfa *✓* Other *Pasture*

4) At what application rate? *750# Per acre*

5) 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 [redacted] 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 *X*

B) More earth worms *X* C) Looser soil *X*

9a) Have you ever experienced any adverse effect with using Bio-Cal? ______

b) If so what effects? ______

Date: *11/1/2000* Signature: *Gerald Klinkner*

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 + PHOS

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: [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 phos magnesium trace minerals and sulfer 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 ✓ 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 Tied 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 in 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: 11-3-00 Signature: Bill Clint

* 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 affect with using Bio-Cal? NO.

b) ~~[illegible]~~? I believe we will see a fall back of our soil nutients and a decrease in our forage tests.

Date: 10/30/00 Signature: [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.
In we can use it again.

Nov 01 00 07:44P Bob & Lorraine Schm...

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: Chuck 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, Phos + 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 affects? ____

Date: 10-30-00 Signature: Tom Bagnewit

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 Grain

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 latter

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? Hell No

b) If so what affects? ____

Date: 10-30-00 Signature: Gregory J. [illegible]

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. Hetrick

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 ____
Alfalfa X 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 X yes

B) More earth worms X Yes C) Looser soil X yes

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

b) If so what affects? ____

Date: 10-27-00 Signature: [signature]

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 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 especialy 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 1.27 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

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

b) If so what effects?

Date: 10/26/00 Signature: [signature]

8

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 [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? 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~~ minerals

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: [signature]

Also: Better yield, Dark color Alfalfa, Solid stem Alfalfa higher Quality- Stands last 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? 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 essentual Nutrie

6) Did you take feed tests on the crops? Feed Test have Improved greatly - higher calcium, phos, magnesium, Trace minerals & especially Sulfur making 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 [illegible]

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 anywhere near this for 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 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

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

b) If so what effects?

Date: 10-29-00 Signature: Robert Schmidknecht

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 Sr

4) At what application rate? 500#

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

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

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

b) If so what affects? ____

Date: 10-30-00 Signature: John Feuker

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: *[signature]

* It gave us better weed control and also helped make better use of our Nitrogen on the corn ground. A must product for Organic.

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, 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 Sulfer 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: [signature]

* A very benifical product for us since we are Organic