

First Things First

***Calcium and Sulfur
Fertilization with
Gypsum***



CALCIUM PRODUCTS

I N C O R P O R A T E D

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Meeting the Challenge

What do corn and soybean growers need to succeed? The same things they have always needed:

- ◆ More control over their business future
- ◆ Higher yields and crop quality
- ◆ Lower input cost per unit of crop output
- ◆ Finely tuned marketing plan
- ◆ Access to an effective problem solver



Growers have little control over global markets, and no control over the weather, but they do have control over what crops they produce, how much it costs to produce them, and their marketing strategy. Growers must concentrate on producing the highest yield for the least cost. By controlling the controllable factors of crop production, growers can maximize production and minimize cost.

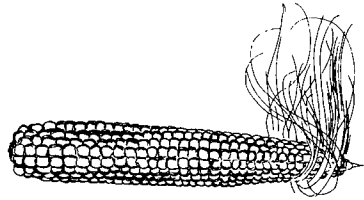
In this booklet you will learn about:

- ◆ The growth and development of corn and soybeans
- ◆ The ingredients of corn and soybean yield
- ◆ The role of calcium and sulfur in plant health
- ◆ Why pelletized gypsum is a superior calcium and sulfur fertilizer
- ◆ Precision concept research results on SuperCal SO₄ pelletized gypsum

The Business of Corn and Soybean Production

The success of a grower's business is measured in bushels per acre. The components that make up bushels of corn are:

- ◆ Ears per acre
- ◆ Rows per ear
- ◆ Kernels per row
- ◆ Kernels per ear
- ◆ Size of kernels produced

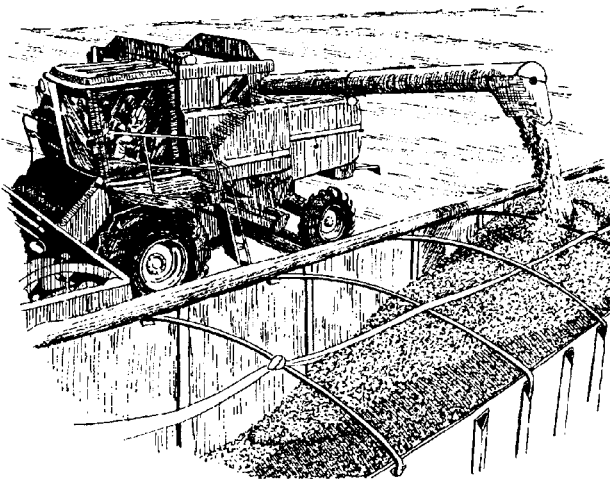


About 18,020,000 kernels must be produced per acre to achieve 200 bu/A corn. The components that make up bushels of soybeans are:

- ◆ Plants per acre
- ◆ Nodes per plant
- ◆ Pods per node
- ◆ Seeds per pod
- ◆ Size of seed produced



At 2,500 seeds per pound about 12 million seeds must be produced per acre to achieve 80 bu/A soybeans.



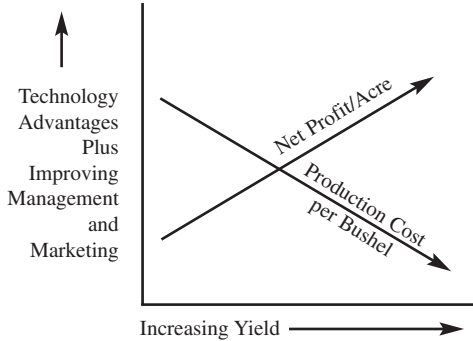
The ingredients of yield include carbon dioxide (CO₂), glucose, water, and nutrients (see table).

Ingredients of Corn and Soybean Yield		
Ingredient	200 bu/A Corn	80 bu/A Soybeans
CO ₂	260,000 semi-trailer loads of air (1,300 loads/bu)	320,000 semi-trailer loads of air (4,000 loads/bu)
Glucose	20,000 lbs (100 lbs/bu)	24,000 lbs (300 lbs/bu)
Water	1,000,000 gal (5,000 gal/bu)	1,080,000 gal (13,500 gal/bu)
Nutrients in seed and stover	300 lbs (1.5 lbs/bu) Nitrogen (33% left in stover)	440 lbs (5.5 lbs/bu) Nitrogen (24% left in stover)
	120 lbs (0.6 lb/bu) Phosphorus (42% left in stover)	96 lbs (1.2 lbs/bu) Phosphorus (29% left in stover)
	260 lbs (1.3. lbs/bu) Potassium (80% left in stover)	192 lbs (2.4 lbs/bu) Potassium (41% left in stover)
	42 lbs (0.21 lb/bu) Calcium (90% left in stover)	136 lbs (1.7 lbs/bu) Calcium (88% left in stover)
	32 lbs (0.16 lb/bu) Sulfur (56% left in stover)	36 lbs (0.45 lb/bu) Sulfur (56% left in stover)

Source: Agri-Growth, Inc.

Producer Profitability

Growers can use new technology and better management practices to increase their net profit per acre. Many good management practices cost little or nothing. As yields go up, production costs per acre also increase, but production costs per bushel go down and cost per unit decreases.



Source: Agri-Growth, Inc., 1999

General relationship between management, production cost, and profit.

Relationship of Corn Yield to Production Cost and Net Profit				
Corn Yield (bu/A)	Gross Revenue* (\$/A)	Production Cost (\$/A) (\$/bu)		Net Profit (\$/A)
100	250	318	3.18	-68
120	300	330	2.75	-30
150	375	345	2.30	30
175	438	368	2.10	70

*Market price: \$2.50/bu

Adapted from 1997. Estimated crop production costs. Iowa Agricultural Statistics, USDA and Iowa Farm Bureau, Des Moines, IA

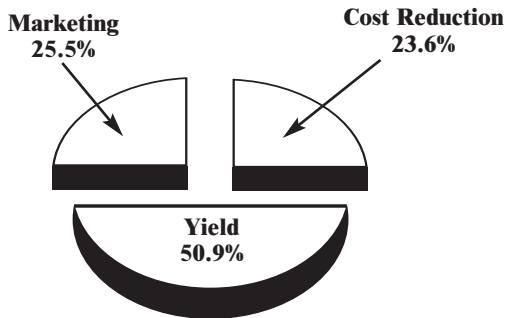
In the table above, 86% of the production costs are already spent to achieve the first 100 bu/A. Spending an extra 14% results in 75 bu/A more corn, an excellent return from a relatively small additional investment.

The Iowa Soybean Association compares the net profit per acre of soybean fields on many Iowa farms in their Producer Profitability Program. In 1998, the growers who produced and marketed their crops in the top 20% received \$157/A more than those who produce and marketed their crops in the bottom 20%.

1998 Differences Realized by Growers in the Top 20%	
Yield Increase	13.3 bu/A
Price Increase	\$0.89/bu
Input Cost Savings	\$37.22/A
Profit Increase	\$157.38

Source: Iowa Soybean Association, 1998

The figure below shows how this increase in net profit was realized.



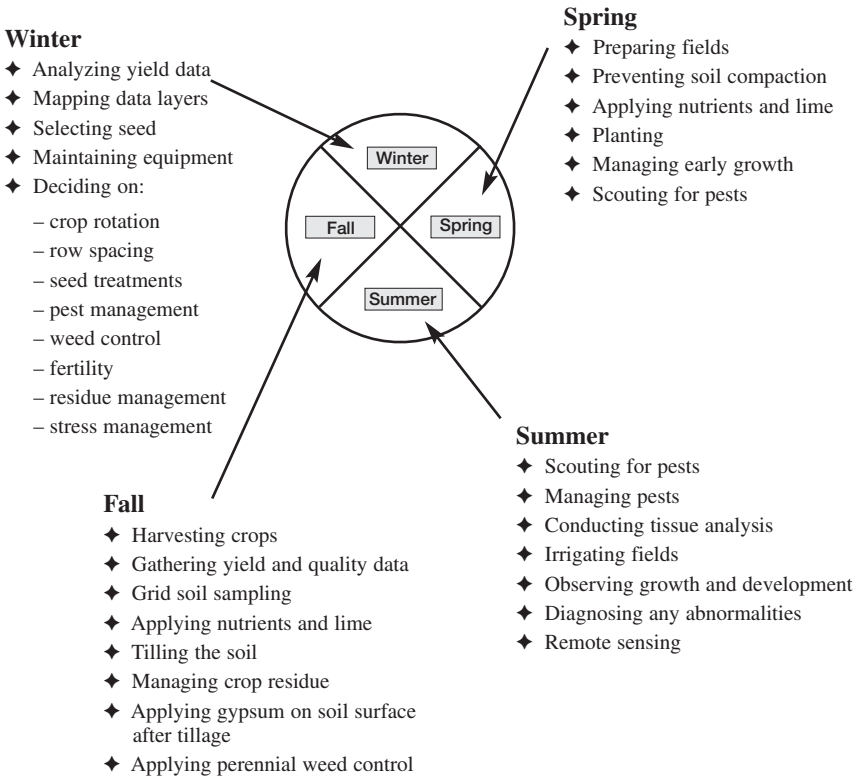
Source: Iowa Soybean Association, 1998

Percent of increase in net profit per acre.

Controlling the Controllables®

Corn and soybean growers must understand the factors that affect crop production and manage as many of them as possible in order to produce as many bushels per acre as possible.

The decisions growers make throughout the year affect their productivity and profitability. The figure below lists the many decisions growers make to control the controllables and shows the cycle in which they are made throughout the year.

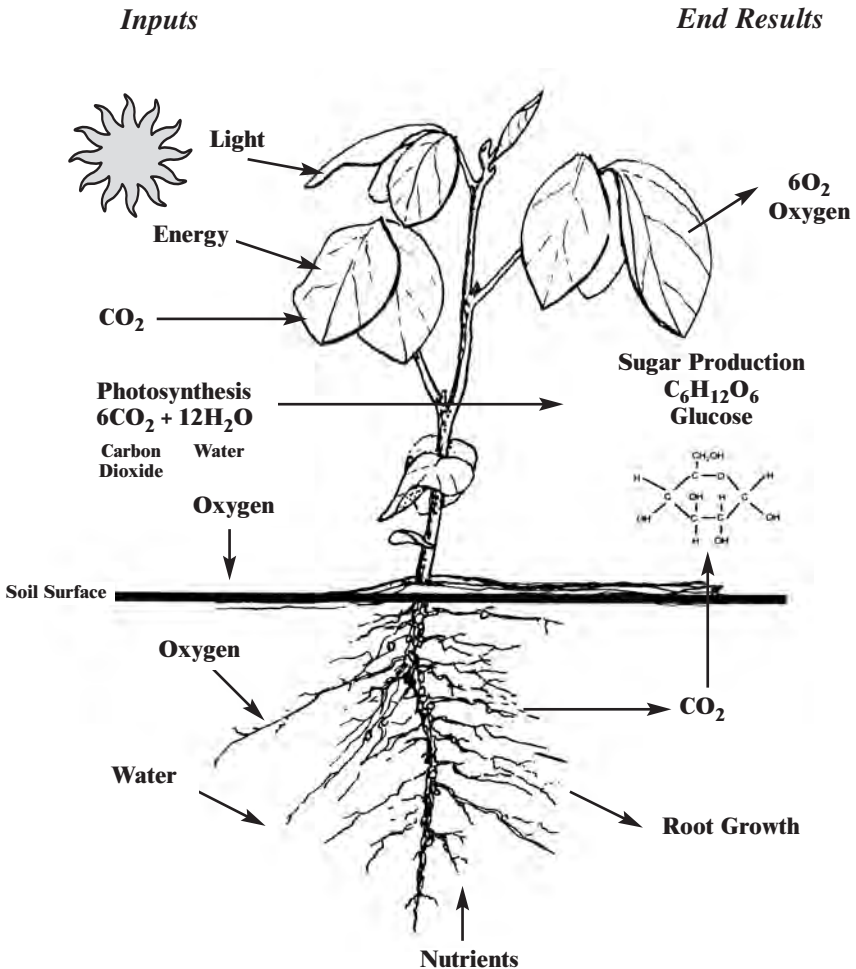


Source: Agri-Growth, Inc.

The crop decision cycle.

The Carbon Cycle

All crop production follows the carbon cycle because carbon is the basic unit of plant dry matter. Simplified, the carbon cycle is when the plant takes carbon from the air, converts it to organic carbon through the process of photosynthesis, and returns it to the soil and air through decomposition.



Source: Agri-Growth, Inc.

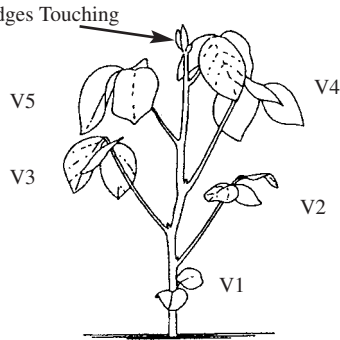
The carbon cycle in soybeans.

Growth and Development

Growers need to be able to identify the stages of corn and soybean growth and development. Both corn and soybean plants have two main stages:

- ◆ Vegetative (V)
- ◆ Reproductive (R)

These two main stages of development are divided into substages.



Source: Agri-Growth, Inc.

Soybean plant at V5.

Identifying stages of soybean growth and development

The V stages are designated as V1, V2, V3, through V(n), except for the first two stages, which are designated as VE (emergence stage) and VC (cotyledon stage). The last V stage is designated as V(n), where (n) represents the number for the last node stage. The subdivisions of the R stages are designated by their common names.

Soybean Vegetative and Reproductive Stages of Development	
Vegetative Stages	Reproductive Stages
VE Emergence	R1 Beginning bloom
VC Cotyledon	R2 Full bloom
V1 First-node	R3 Beginning pod
V2 Second-node (1 st Trifoliolate Leaf)	R4 Full pod
V3 Third-node (2 nd Trifoliolate Leaf)	R5 Beginning seed
	R6 Full Seed
	R7 Beginning maturity
	R8 Full maturity
V(n) nth-node	

Source: How a soybean plant develops. 1996. Special Report No. 53. Iowa State University, Ames, IA

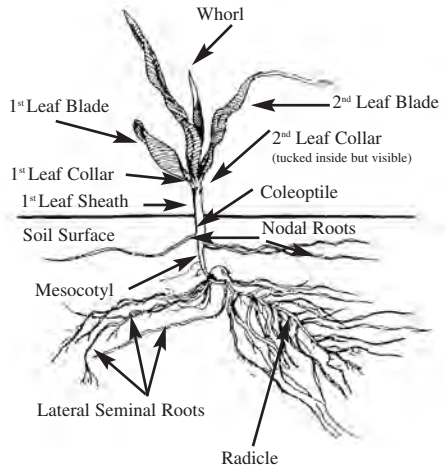
Identifying stages of corn growth and development

Emergence is designated VE. The next vegetative substages are numbered V1, V2, V3, and so on, through V(n), where (n) represents the last leaf stage before VT or tasseling. The total number of leaves before tasseling is determined by the hybrid and environment.

Reproduction begins with silking (R1) and goes through six substages to physiological maturity (R6).

The stage of an individual corn plant can be accurately defined according to the uppermost leaf with a visible leaf collar. Leaf collars are visible in the back or underside of the leaf. The oval-shaped first leaf is a reference point for counting upward to the top visible leaf collar.

Not all plants in a field will be at the same stage at the same time. A field of corn is defined as being at a specific V or R stage when 50% or more of the plants are at or beyond that stage.



Source: Agri-Growth, Inc., 1998

The corn plant at V2 stage when the second leaf collar is visible.

The Stages of Corn Growth and Development	
Vegetative	Reproductive
VE Emergence	R1 Silking
V1 First leaf	R2 Blister
V2 Second leaf	R3 Milk
V3 Third leaf	R4 Dough
V(n) nth node	R5 Dent
VT Tasseling	R6 Physiological maturity

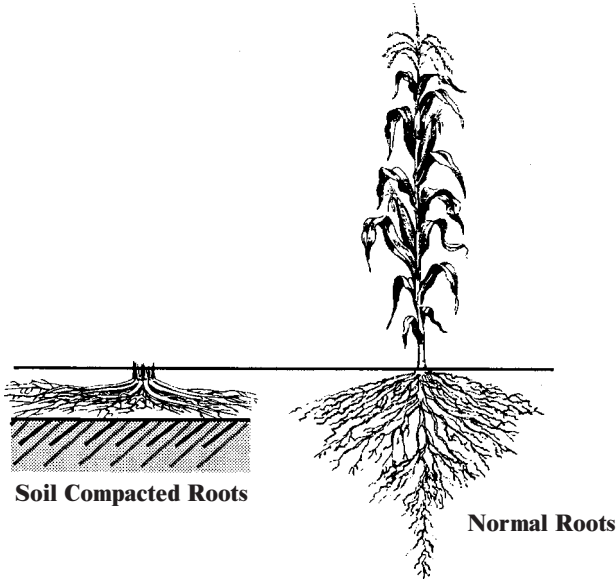
Source: How a corn plant develops. 1993. Special Report No. 48. Iowa State University, Ames, IA

Profit Impact Factors

The following factors affect yield and profitability:

- ◆ Hybrid/variety selection
- ◆ Stand establishment
- ◆ Planting date
- ◆ Early weed competition
- ◆ Herbicide stress
- ◆ Diseases
- ◆ Soil compaction and drainage
- ◆ Soil pH
- ◆ Soil nutrient availability

Growers who make good decisions about these factors can increase the productivity of their crops.



Source: Agri-Growth, Inc.,

Soil compaction limits corn root growth and yield.

Nutrient Relationship to Plant Functions

Each nutrient a plant requires functions as part of a delicately balanced interdependent system. This system is controlled by the plant's genetic composition and the physical and biological environment of the soil.

The plant's efficiency in using nutrients for grain yield is influenced by:

- ◆ Rate of uptake
- ◆ Source of the nutrient
- ◆ Form of the nutrient
- ◆ Time of application or availability

Relationship of Nutrient Elements to Plant Functions			
Plant Function	Mineral Elements Involved		
Photosynthesis	Nitrogen Phosphorus Potassium	Manganese Magnesium Sulfur	Iron Chlorine
Enzyme Regulation	Nitrogen Phosphorus Potassium Calcium	Magnesium Iron Zinc Molybdenum	Sulfur Manganese Copper
Protein Synthesis	Nitrogen Phosphorus Sulfur	Magnesium Manganese Molybdenum	Iron Boron
Carbohydrate Metabolism	Phosphorus Calcium Molybdenum	Magnesium Manganese	Iron Boron
Nitrogen Metabolism	Nitrogen Phosphorus Potassium	Calcium Zinc	Manganese Molybdenum
Hormone Synthesis	Manganese	Zinc	Copper
Osmotic Pressure	Potassium Sodium	Chlorine	Calcium
Translocation	Potassium	Boron	Chlorine
Grain Yield	All Essential Elements		

Maximizing Soil Fertility

Corn and soybeans need the right nutrients in the right amounts at the right stages of development. The following table shows percent nutrient uptake at corn growth stages.

Corn Growth Stages and Nutrient Uptake						
% Nutrient Uptake						
Stage	V3 – V4	V5 – V10	V11– R1	R2 – R5	Physiological Maturity R6	Total
N	8	35	31 (74)	20	6	100
P ₂ O ₅	4	27	36 (67)	25	8	100
K ₂ O	9	44	31 (84)	14	2	100
Ca	2	24	50 (76)	28	5	100
S	2	12	28 (42)	50	8	100
				Cannibalization		

Source: Karlen, D.L, R.L. Flannery, and E.J. Sadler. 1988. Aerial accumulation and partitioning of nutrients by corn. *Agronomy Journal* 80:232-242

The following table shows the total nutrients required for a 200 bu/A corn crop, the nutrients left in the stover, and the nutrients removed in the grain.

Total Nutrient Requirements for 200 bu/A Corn Crop, Nutrients Remaining in Stover and Nutrients Removed as Grain			
Nutrient	Total Nutrient Uptake (lbs/A)	Nutrients Remaining in Stover (lbs/A)	Nutrients Removed as Grain (lbs/A)
Nitrogen (N)	300	99	201
Phosphate (P ₂ O ₅)	120	50	70
Potash (K ₂ O)	260	208	52
Calcium (Ca)	42	38	4
Sulfur (S)	32	18	14

Source: Adapted from Barber, S.A. and R.A. Olson. 1968. Fertilizer use on corn. p. 163-188. In *changing patterns in fertilizer use*. L.B. Nelson et al., eds. SSSA, Madison, WI

The following table shows percent nutrient uptake at soybean growth stages.

Soybean Growth Stages and Nutrient Uptake						
	% Nutrient Uptake					
Stage	V1 – V2	V3 – V6	R2	R3 – R4	R5 – R7	Total
N	5	3	23 (31)	25	44	100
P ₂ O ₅	5	4	21 (30)	26	44	100
K ₂ O	6	7	21 (34)	34	32	100
Ca	7	5	18 (30)	31	38	100
S	0.6	0.4	33 (34)	28	38	100
					Cannibalization	

The following table shows the total nutrients required for an 80 bu/A soybean crop, the nutrients left in the stover, and the nutrients removed in the grain.

Total Nutrient Requirements for 80 bu/A Soybean Crop, Nutrients Remaining in Stover and Nutrients Removed as Grain			
Nutrient	Total Nutrient Uptake (lbs/A)	Nutrients Remaining in Stover (lbs/A)	Nutrients Removed as Grain (lbs/A)
Nitrogen (N)	440	106	334
Phosphate (P ₂ O ₅)	96	28	68
Potash (K ₂ O)	192	79	113
Calcium (Ca)	136	120	16
Sulfur (S)	36	20	16

Source: Adapted from 1987. Agronomy handbook. Midwest Laboratories, Omaha, NE

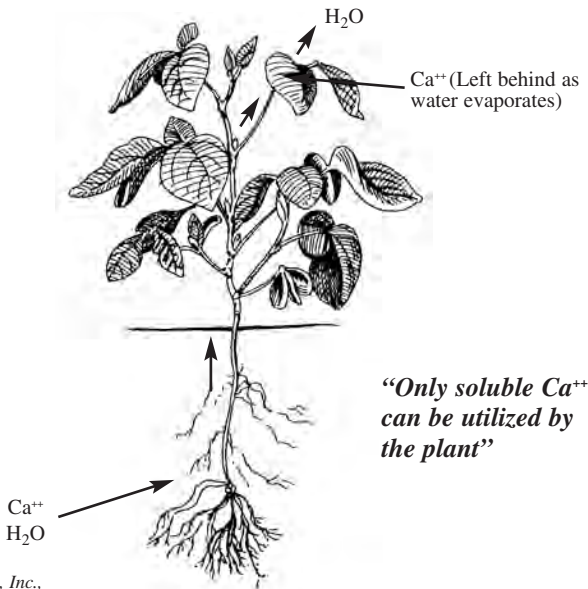
Calcium and Sulfur in the Plant

Calcium and sulfur affect crop growth and development and must be managed.

What is the impact of calcium on growth and development?

Calcium strengthens plant cell walls. Cell walls will be weak in any part of the plant where calcium is in short supply. If cell walls are weak it is easier for fungi and bacteria to break through the plant's natural defenses.

Calcium (Ca^{++}) is not mobile within the plant. Roots absorb calcium with water. Calcium and water are transported to leaves where the water evaporates through small pores (stomates). Calcium concentration in the plant is greatest where water has evaporated. This is why lab tests of leaves hardly ever show a shortage of calcium. The calcium concentration in roots, thick stems, fruits and flowers is less because less water evaporates from these structures.



Source: Agri-Growth, Inc.,

Calcium is absorbed with water by roots, transported to leaves, and left behind as water evaporates through leaf pores.

Calcium defends plants against diseases

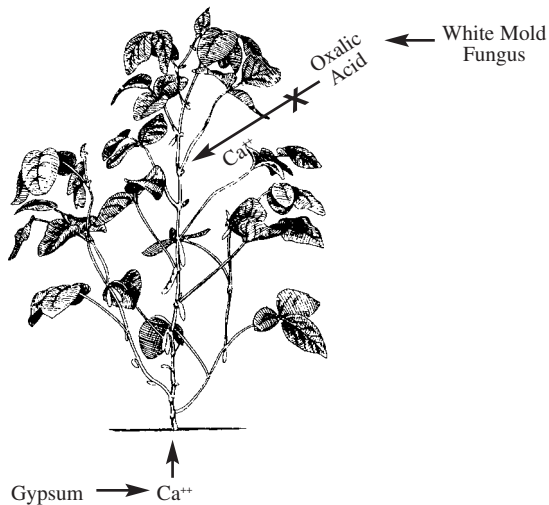
Scientific research has found that higher levels of free calcium (dissolved in water) in the soil and in the plant can reduce diseases or conditions caused by:

- ◆ Fungi—Stem, pod and root rots
- ◆ Bacteria—Pod and fruit rots
- ◆ Calcium deficiencies—Blossom end rots and empty pods

Calcium fights diseases in the following ways:

- ◆ It strengthens plant cell walls by holding together pectin, a gelling substance.
- ◆ It slows down the digestion of cell walls by fungal enzymes; therefore, the fungi cannot invade the plant cells.
- ◆ It neutralizes the oxalic acid produced by the white mold fungus.

White mold (*Sclerotinia sclerotiorum*) attacks soybeans through flowers and small pods. It produced oxalic acid, which extracts calcium from the pectin that holds together cell walls. This causes cell walls to collapse. University research is likely to prove that gypsum increases calcium levels in the flowers and small pods and neutralizes oxalic acid produced by white mold.



Source: Agri-Growth, Inc.

Calcium neutralizes (X) oxalic acid from the white mold fungus.

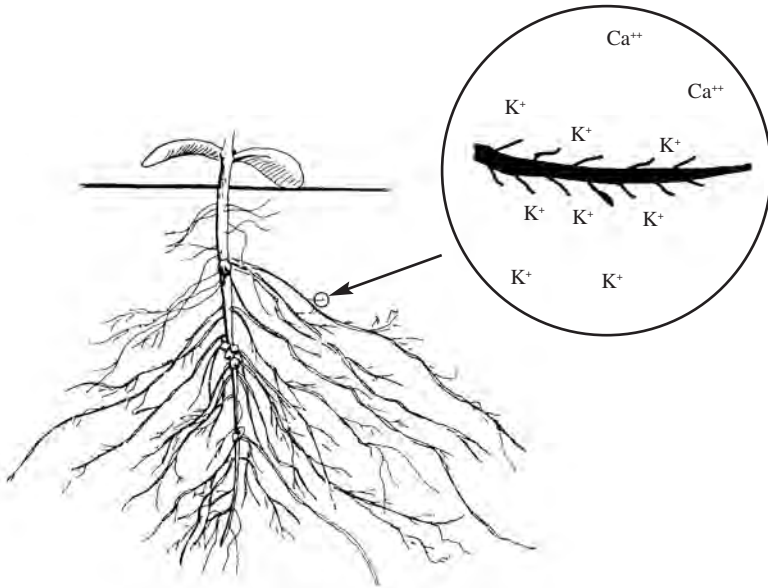
Potassium competes with calcium

Potassium (K^+) and calcium (Ca^{++}) appear the same to plant roots and are absorbed at about the same rate. Some reasons include:

- ◆ Potassium weighs 39 grams and calcium 40 grams per mole (a mole is a unit of measurement of chemical weight).
- ◆ The electrical charge of K is +1, and the electrical charge of Ca is +2.

If the soil around the roots contains an abundance of potassium, an excess amount will be absorbed at the expense of calcium. The result is a calcium deficiency and an increase in disease and poor seed quality.

Competition between potassium and calcium is most evident in peanuts, a crop where calcium deficiency near the developing pods results in empty pods called “pops.” To avoid pops, growers apply potassium the season before planting peanuts so it can leach below the top several inches where pods grow. For highest yields gypsum is applied near the pod zone to boost the free calcium level and overwhelm nearby potassium.



Source: Agri-Growth, Inc.,

Too much K^+ overwhelms Ca^{++} .

Calcium from gypsum protects crop roots

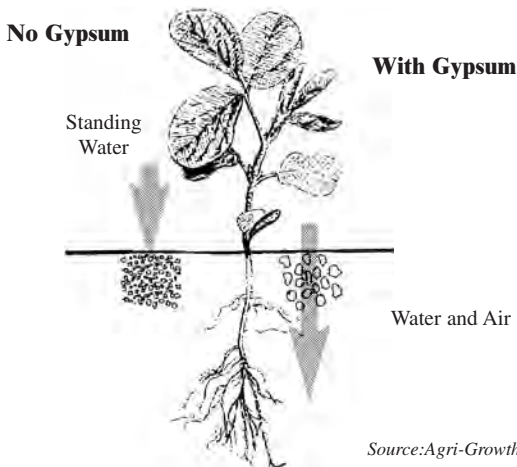
Adding pelletized gypsum causes changes in soil structure. Gypsum reduces:

- ◆ High sodium saturation
- ◆ Waterlogging and low oxygen
- ◆ Poor soil structure
- ◆ High pH
- ◆ Micronutrient deficiencies such as iron chlorosis in soybeans
- ◆ Low calcium to magnesium ratios

The main reason for the observed soil changes is that gypsum releases a high rate of free calcium up to a soil pH of approximately 8.5. Limestone, on the other hand, releases less free calcium at soil pH above 7.0.

When applied near the root zone, this free calcium:

- ◆ Saturates the soil solution with calcium
- ◆ Displaces sodium and potassium from the soil particles (colloids)
- ◆ Makes neighboring soil particles form stable aggregates
- ◆ Opens drainage channels so standing water drains to subsoil
- ◆ Binds organic matter to soil to stabilize soil aggregates



Source: Agri-Growth, Inc., 1999

Gypsum helps soil drain and aerate.

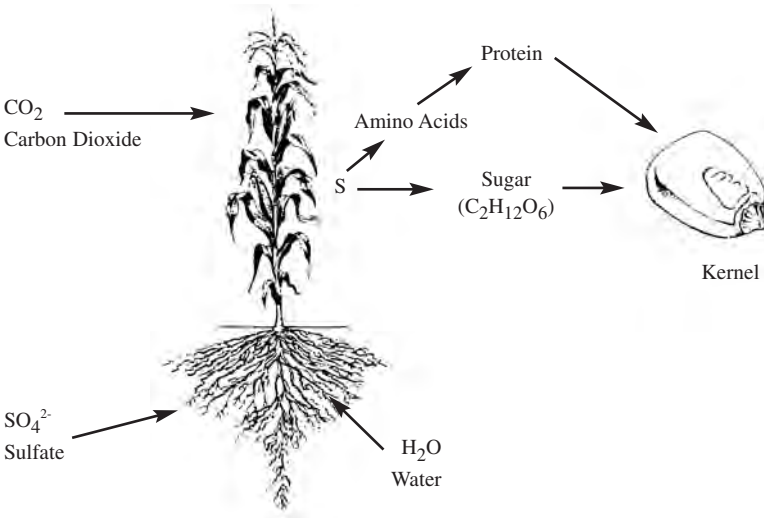
What is the impact of sulfur on growth and development?

Sulfur is an active ingredient in growing plants and is needed to build two of the essential amino acids, cysteine and methionine. Without these amino acids, proteins cannot be built and plants will not grow.

Sulfur is not very mobile within the plant:

- ◆ Roots take up sulfur as sulfate (SO_4^{2-})
- ◆ Sulfate moves with water to the leaves
- ◆ Sulfate is built into organic compounds
- ◆ These organic compounds move anywhere proteins are being made
- ◆ Sulfur is locked up once proteins are made

Sulfur deficiency usually causes yellowing of younger leaves as well as stunted growth and delayed maturity. Yellow color in new growth is even greater with sulfur deficiency than nitrogen deficiency because both are needed to make green chlorophyll. However, nitrogen is more mobile. The best way to test for sulfur deficiency is a laboratory analysis of young leaves.



Source: Agri-Growth, Inc.

Corn plants use sulfur to produce amino acids that in turn produce proteins

Nitrogen needs sulfur to do its job in the plant

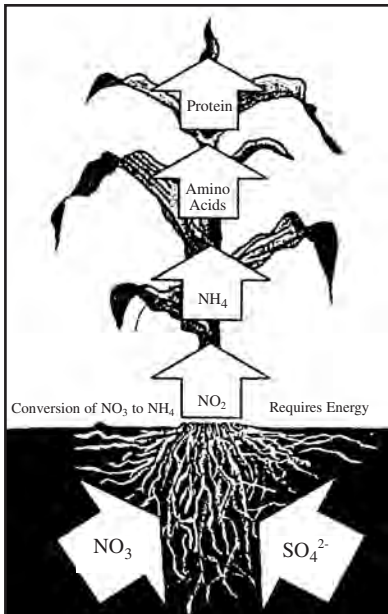
Most growers are concerned about applying enough nitrogen to non-legumes but do not realize that sulfur is key to nitrogen use. An adequate supply of sulfur is needed in order for plants to use nitrogen.

Because both nitrogen and sulfur are building blocks in protein, a deficiency of either results in shortages of enzymes such as:

- ◆ Chlorophyll, the substance which converts sunlight to usable energy
- ◆ Rubisco, the enzyme which changes carbon dioxide into sugar
- ◆ Nitrate reductase, the material which converts plant nitrate into ammonium

Sulfur deficiency disrupts growth processes such as:

- ◆ Photosynthesis (due to lack of chlorophyll)
- ◆ Nitrogen fixation in legumes like soybeans
- ◆ Conversion of nitrate into ammonium and protein
- ◆ Formation of storage proteins in developing seeds



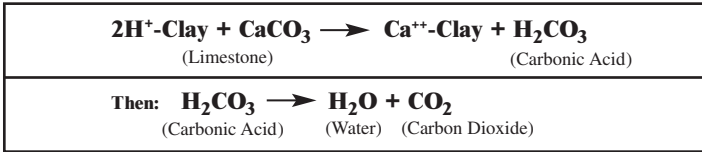
Source: Agri-Growth, Inc.

Nitrate nitrogen must be converted to ammonium nitrogen before plant use. Sulfate (SO_4^{2-}) is needed to make this happen.

Fertilizing with Calcium and Sulfur

Limestone as a calcium fertilizer

Applying lime (CaCO_3) to raise pH of acid soils also produces exchangeable Ca^{++} like Ca^{++} -Clay. Lime works by converting acidifying H^+ ions into H_2O :



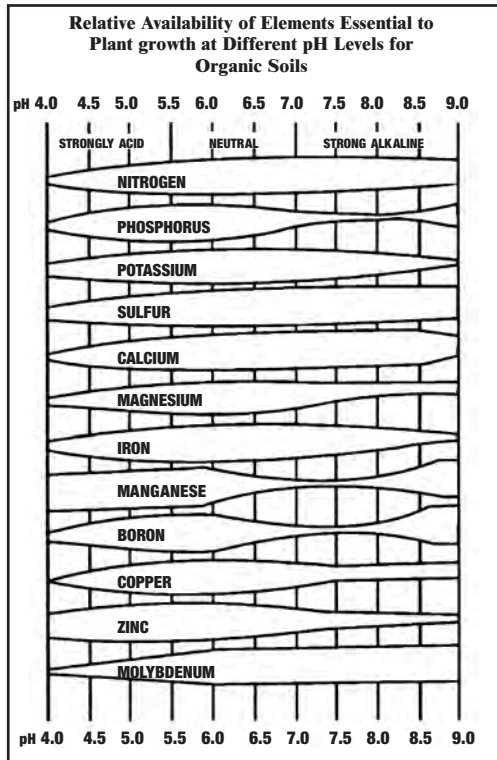
The exchangeable Ca^{++} (Ca^{++} -Clay) can then be solubilized and taken up by the plant.

The optimum pH level for soybeans and corn is around 6.8, just under the neutral pH of 7.0. Advantage of a pH below 7.0 include:

- ◆ Most plant nutrients are available
- ◆ More nitrogen is fixed in legumes
- ◆ More microbes are active
- ◆ Herbicides and fertilizers perform better

Source: Truog, E. 1946. Soil Science Society of America, Prog. 11: 305-308

Most nutrients are more readily available at a pH below 7.0



Calcium fertilization in high pH soils

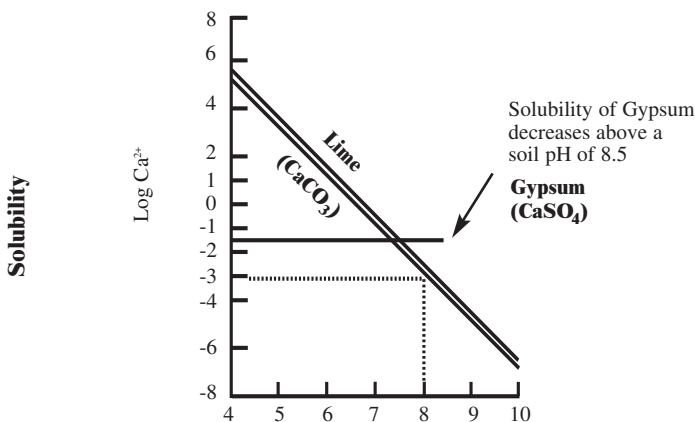
What if a grower wants to fertilize with calcium in a field that already has soil pH above 7.0? High pH soils can occur if:

- ◆ High rates of lime were applied in past years
- ◆ Soil parent material is calcareous, sodic or saline
- ◆ Irrigation water is high in soluble salts (Ca, Mg, Na)

Limestone (calcium carbonate) becomes less soluble than gypsum between pH 7.0 to 8.3. This is when gypsum is really needed because:

- ◆ Gypsum can release free calcium up to soil pH of approximately 8.5
 - $\text{CaSO}_4 \longrightarrow \text{Ca}^{++} + \text{SO}_4^{-}$
- ◆ Only high sulfate and HCO_3^- concentration slows the dissolution of gypsum

As the pH of the soil rises above 7.0, bicarbonate (HCO_3^-) and carbonates ($\text{CO}_3^{=}$) increase, raising the soil pH. Free calcium from gypsum lowers the concentration of both and can drop the soil pH from 8.0 to 7.3. This helps drop the soil pH in the root zone, increase nutrient availability and reduce the toxic compounds (HCO_3^- and $\text{CO}_3^{=}$) that negatively impact plant growth, especially soybeans.



Source: Adapted from Lindsay, W.L. 1979. *Chemical equilibria in soils*. Wiley Interscience

Soil pH above 7.0 affects solubility of lime, but gypsum is soluble up to a soil pH of approximately 8.5.

Sulfur fertilization with gypsum

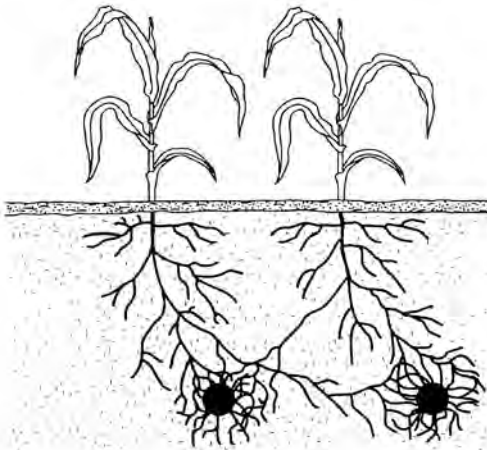
Legumes accumulate equal amounts of sulfur and phosphorus, while cereals absorb $\frac{1}{3}$ less sulfur than phosphorus. Gypsum is the earliest known sulfur fertilizer and was applied to pastures in Switzerland as far back as 1768. The practice quickly spread to Europe and America, but was replaced by widespread use of sulfur-containing superphosphate and ammonium sulfate.

Sulfur deficiencies have returned in recent decades with:

- ◆ Adoption of low-sulfur fertilizer after World War II
- ◆ Switch from high-sulfur coal to low-sulfur petroleum
- ◆ Use of smoke stack scrubbers in industrial furnaces

About 90% of available sulfur is tied up in organic matter. Other fractions are leached into the subsoil. Fertilizing with pelletized gypsum reduces any sulfur deficiencies because:

- ◆ It contains about 17% sulfur
- ◆ Gypsum releases free sulfate that is absorbed by plant roots
- ◆ It dissolves unless soil sulfate is more than 700 lbs/A of S



Source: Agri-Growth, Inc.

Roots concentrate in a fertilizer band because they respond to fertility.

Application rates of pelletized gypsum

Ordinary landplaster gypsum is usually applied at rates over a ton per acre, similar to limestone. Higher amounts are needed because the extra-fine particles cling together and do not disperse well to cover the field.

Pelletized gypsum is made of fine particles aggregated together. The pellets break apart in the field when wet.

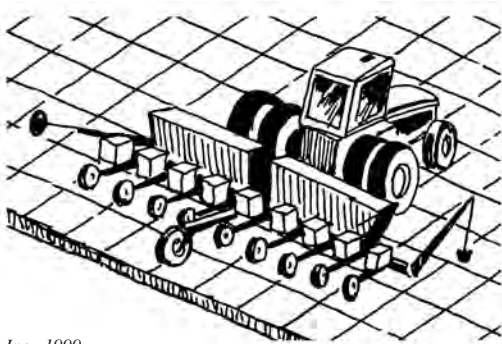
For best soil conditioning effects, gypsum should be broadcast after tillage in the fall or winter, or in the spring prior to the last tillage before planting. A pre-plant broadcast rate of 300 lbs/A of pelletized gypsum is adequate for corn or soybeans.

Gypsum is entirely seed safe, and can be applied directly in the seed furrow to saturate the root zone with free calcium. Gypsum will acidify the root zone of high pH soils and often reduce iron chlorosis in soybeans.

Some growers have used air seeders to apply pelletized gypsum at planting as a band over the row or in the seed furrow. They put seed in one tank and pelletized gypsum in the other tank. Because the gypsum is applied in narrow strips in the field, a reduced rate can be used:

- ◆ 70 to 100 lbs/A for 30 inch rows
- ◆ 140 lbs/A for 15 inch rows

Narrow rows require more gypsum to get the same amount per foot of row (one ounce of gypsum per 15½ feet of row).



Source: Agri-Growth, Inc., 1999

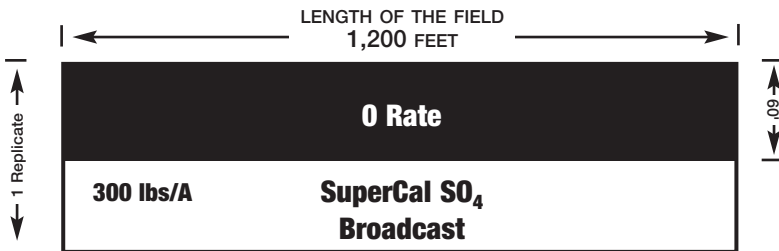
Pelletized gypsum can be applied at planting with the soybean seed.

Results From Precision Concept Research

Precision concept research is research in actual commercial field situations and uses precision farming technologies to examine product efficacy. Field-sized plots are planted and harvested with conventional farm equipment outfitted with GPS equipment. Results from precision concept research reflect the results growers can expect to see in their own fields.

SuperCal SO₄ pelletized gypsum was tested in field conditions during the 1998 season. A 20-acre field of soybeans was planted with Stine 2500 seed on May 16, 1998 at the rate of 58 lbs/A. The soybean field had a soil pH of 7.7. The field was divided into five replicates, each 1,200 feet long and 120 feet wide. Each replication received the following treatments:

- ◆ 300 lbs/A of SuperCal SO₄ pelletized gypsum
- ◆ No added gypsum



Source: Agri-Growth, Inc.

One replicate in the precision concept research study on SuperCal SO₄ pelletized gypsum.

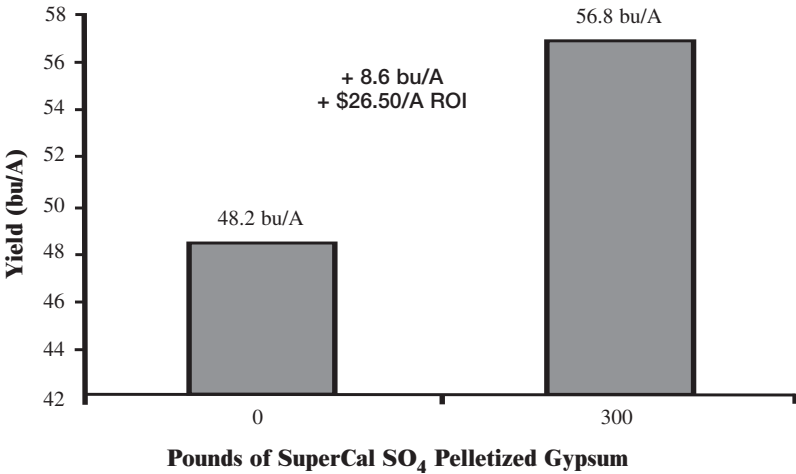
The pelletized gypsum was broadcast and incorporated before planting, allowing time for the product to dissolve into calcium and sulfur. No other changes were made to how the soybeans were grown.

Gypsum increased soybean yield 18%

SuperCal SO₄ pelletized gypsum increases soybean yields when broadcast and incorporated before planting. Precision concept research in 1998 compared infield plots with and without 300 lbs/A pelletized gypsum.

A 20-acre field was divided into 5 replications, 1,000 feet by 80 feet. Half of each replicate was broadcast with 300 lbs/A of SuperCal SO₄ pelletized gypsum in March. The entire field was tilled with a field cultivator and planted in May 18 with Stine 2500 soybeans.

The plots treated with pelletized gypsum yielded 18% more than the plots that did not receive gypsum. This was an 8.6 bu/A increase. At an investment of \$16.50/A for the gypsum, if soybeans sold for \$5.00/bu, the additional income would be \$26.50/A. Every dollar invested in pelletized gypsum would return \$1.60 in benefits.



Source: Agri-Growth, Inc., 1998

1998 SuperCal SO₄ study on soybeans.

Statistical Analysis of Yield

The Duncan's MRT indicates statistical separation between the two treatments 56.8 bu/A and 48.2 bu/A, at the 95% confidence level.

Gypsum on soybean fields with White Mold

White mold (*Sclerotinia sclerotiorum*) became a problem in a soybean field during 1998. Researchers observed the large plots treated with 300 lbs/A SuperCal SO₄ pelletized gypsum had considerably less white mold than the plots that were not treated.

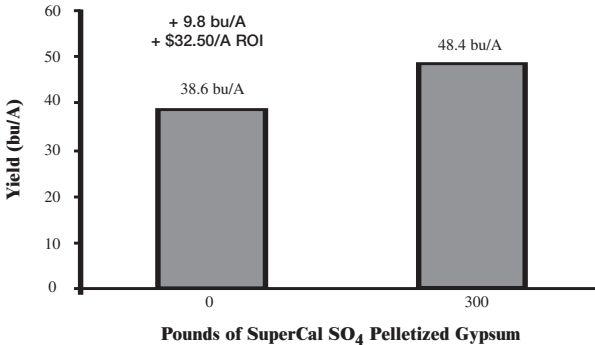
The visual observations were supported by the yield monitor readings. About 7,000 yield readings were recorded from all 10 plots. Each reading is the yield from an area of about 100 square feet.

The five plots that did not receive SuperCal SO₄ pelletized gypsum produced an average yield of 38.6 bu/A. This is about 20% less than the 48.4 bu/A average for plots that received gypsum. Pelletized gypsum reduced the white mold infection and produced greater soybean yields.



Source: Robert F. Nyvall, Professor, University of Minnesota

Plant symptoms of white mold.

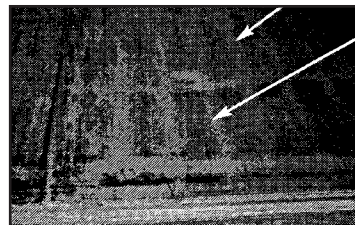


Source: Agri-Growth, Inc., 1998

Gypsum gave a 9.8 bu/A yield advantage in soybeans with white mold.

Source: Agri-Growth, Inc.

Aerial image of white mold in soybeans showing treatment differences (lighter areas).



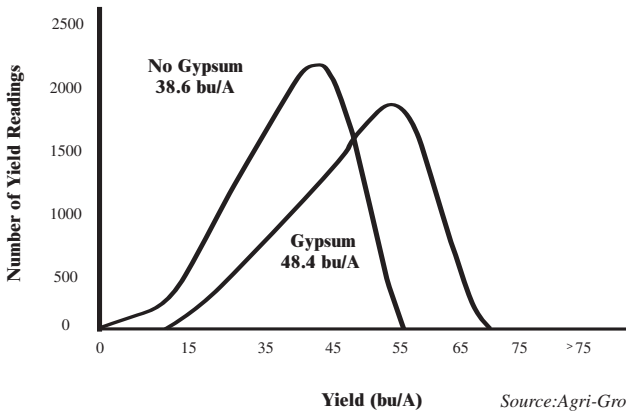
Pelletized gypsum + soybeans = ROI

An early spring broadcast application of SuperCal SO₄ pelletized gypsum gave a soybean yield advantage of 10 bu/A in a wet field with white mold infestation.

Using \$5/bu soybeans, SuperCal SO₄ pelletized gypsum:

- ◆ Cost \$16.50/A for a 300 lbs/A broadcast application
- ◆ Increased total income from \$193 to \$242/A
- ◆ Produced additional income of \$32.50/A
- ◆ Returned \$2 for every \$1 invested

If a grower were able to apply SuperCal SO₄ pelletized gypsum with the seed at planting, the rate could be reduced from 300 lbs/A to about 70 lbs/A. With a similar yield increase, the economics would be even more favorable.



In Soybeans with white mold there was a 9.8 bu/A yield advantage with gypsum.

Statistical Analysis of Yield

The Duncan's MRT indicates statistical separation between the two treatments; 48.4 bu/A and 38.6 bu/A, at the 95% confidence level.

Source: Agri-Growth, Inc.

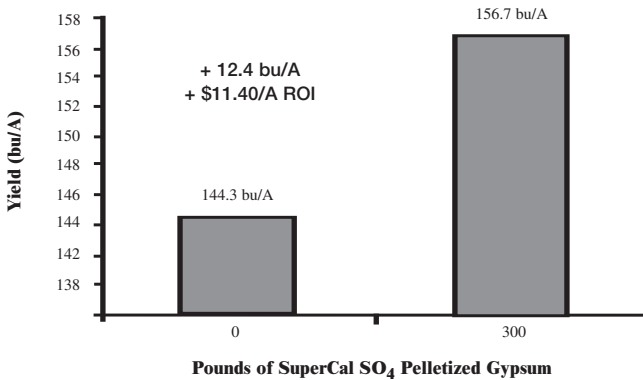
Corn yield increases from pelletized gypsum

The importance of applying pelletized gypsum to corn was proved by precision concept research on a heavy, high-organic matter soil of pH 7.5 in southern Minnesota.

Before planting, 300 lbs/A of pelletized gypsum was broadcast and incorporated in five replicates 1,000 feet long and 40 feet wide. The corn yield from these five replicates was compared to adjacent blocks that were not treated with gypsum.

Applying SuperCal SO₄ pelletized gypsum increased yield 12.4 bu/A, compared to fields not treated. Using \$2.25/bu corn, the economics show:

- ◆ An investment of \$16.50/A for 300 lbs/A
- ◆ Increased total income from \$325/A to \$353/A
- ◆ Produced \$11.50 additional income per acre
- ◆ Returned 70 cents for every \$1 invested



Source: Agri-Growth, Inc., 1998

Field corn–SuperCal SO₄ study–1998.

Statistical Analysis of Yield
The Duncan's MRT indicates statistical separation between the two treatments 156.7 bu/A and 144.3 bu/A, at the 95% confidence level.

Source: Agri-Growth, Inc.

Pelletized gypsum + alfalfa = extra income

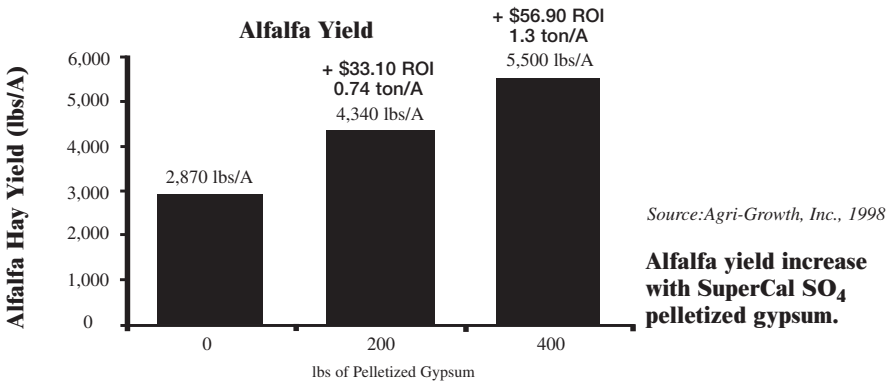
SuperCal SO₄ pelletized gypsum was tested on alfalfa in 1998. The 20-acre field had a soil pH of 7.3. It was divided into five replicates, each a total of 800 feet long by 120 feet wide. Each block was split into three treatments:

- ◆ No added Gypsum
- ◆ 200 lbs/A gypsum
- ◆ 400 lbs/A gypsum

The SuperCal SO₄ pelletized gypsum was broadcast and incorporated before the AgriPro Defiant® alfalfa was planted on April 30 at 16 lbs/A. The alfalfa was cut three times, and yields were added to produce a season total.

With alfalfa at \$60/ton, SuperCal SO₄ pelletized gypsum:

- ◆ Cost \$11 for 200 lbs/A and \$22 for 400 lbs/A
- ◆ Increases total income from \$86 (no gypsum) to \$130/A (200 lb/A gypsum) to \$165/A (400 lb/A gypsum)
- ◆ Produced additional income from \$33/A (200 lb/A gypsum) to \$57/A (400 lb/A gypsum)
- ◆ At 200 lbs/A returned \$3.00 for every \$1.00 invested

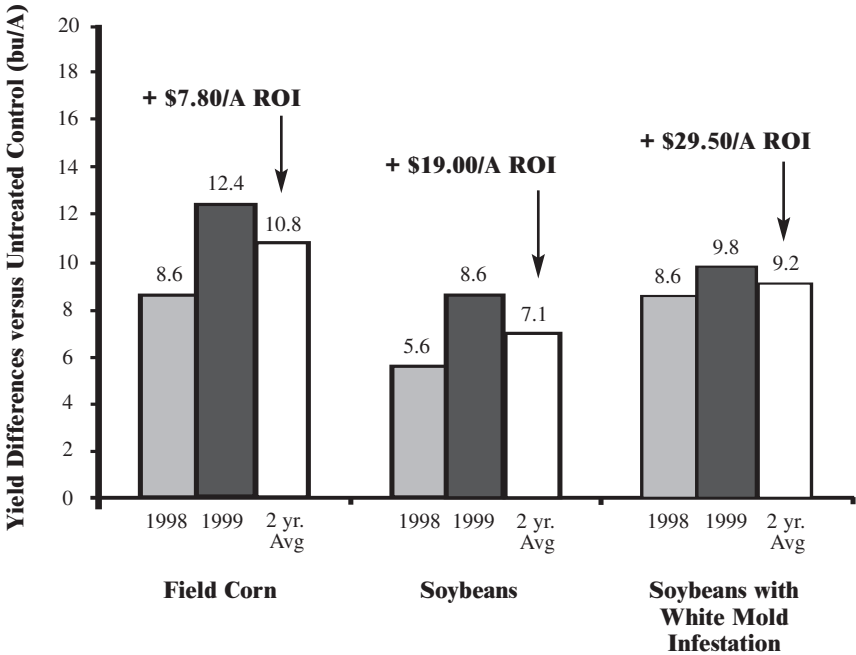


Statistical Analysis of Yield

The Duncan's MRT indicates statistical separation between the three treatments 5,500 lbs/A, 4,340 lbs/A and 2,870 lbs/A at the 95% confidence level.

Source: Agri-Growth, Inc.

1998 and 1999 Summary of the Yield Advantage of Using SuperCal SO₄ on Corn and Soybeans^{1,2,3}



¹ SuperCal SO₄ was applied at 300 lbs/A broadcast

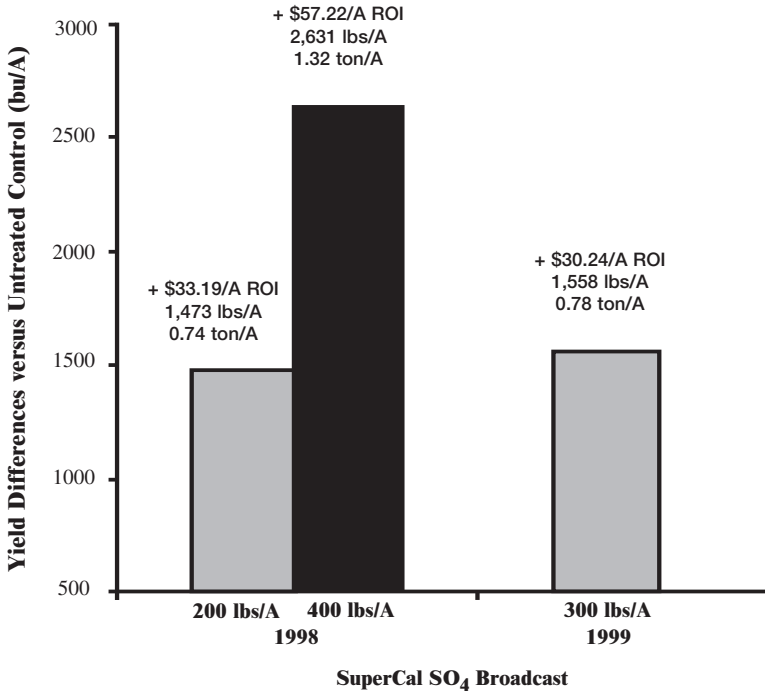
² ROI = corn at \$2.25/bu, Soybeans at \$5.50/bu and pelletized SuperCal SO₄ at \$16.50/300 lbs.

³ Location: Hollandale, MN

Statistical Analysis of Yield

The Duncan's MRT indicates statistical separation between the treated and untreated for the studies above at the 95% confidence level.

1998 and 1999 Summary of The Yield Advantage of Using SuperCal SO₄ on Alfalfa ^{1,2,3}



¹ Average total yield of three cuttings

² ROI = Alfalfa at \$60.00/ton and pelletized SuperCal SO₄ at 200 lbs = \$11.00, 300 lbs = \$16.50, 400 lbs = \$22.00

³ Location: Hollandale, MN

Statistical Analysis of Yield

The Duncan's MRT indicates statistical separation between the treated and untreated for the studies above at the 95% confidence level.

Use of Pelletized Gypsum

Pelletized gypsum can be:

- ◆ Applied in the fall to provide the greatest impact on soil structure
- ◆ Spring broadcast to enhance early calcium and sulfur availability
- ◆ Placed in zones with N, P, & K to improve drainage and calcium availability
- ◆ Easily blended and spread with other dry fertilizer products
- ◆ Applied at moderate rates and still achieve significant yield responses (200 to 300 lbs/A)

Gypsum is not toxic to seed or young plants when placed in the seed furrow or banded over the top.

Benefits of Pelletized Gypsum

In conclusion, SuperCal SO₄ pelletized gypsum offers these benefits to corn and soybean growers:

- ◆ Improves plant health and productivity
- ◆ Is an excellent source of readily available calcium and sulfate for the plant at all soil pH levels
- ◆ The sulfate improves nitrogen utilization and fixation by legumes like soybeans
- ◆ Helps manage micronutrient deficiencies such as iron chlorosis in soybeans
- ◆ Improves soil structure, aeration, drainage, and rootability of plants in conventional and especially no-till soils
- ◆ Reduces soil surface crusting and improves seedling emergence
- ◆ Will reduce the soil pH of sodic soils and help create the optimum calcium/magnesium ratio (4:1) in your soil
- ◆ Helps fight diseases caused by fungi, such as white mold



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